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THE EAST IN EARLY NINETEENTH CENTURY ENGLISH POETRY*

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Early References—

Since the days of Chaucer down to the close of the eighteenth century, English poets had frequently drawn upon the East for inspiration. As early as the first half of the fourteenth century, Chaucer's Knight had been with the Lord of Palatye " agayn an hethen in Turkye," and had fought beside renowned monarchs in several theatres of war in the East. In the Elizabethan period, Marlowe wrote a play on *Tamburlaine;* in Shakespeare the references are many. Oberon's fairy kingdom lay in the Far East—" the farthest steep of India "—while the Venetian Antonio's

* This is the first paper on the subject of The East in Romantic Literature. Fiction and Drama will be dealt with by other scholars in subsequent years.—A. Jha.

trade extended to Eastern waters; ultimately when his ventures fail, not one boat returns,

> " From Tripolis, from Mexico and England,
> From Lisbon, Barbary and India."

In the Caroline age, Milton makes excursions to the East in *Paradise Lost*. He speaks " of Ganges or Hydaspes, Indian streams," and later refers to " Agra and Delhi of Great Mogul," both places of world-wide repute in his days. In the Augustan period, Dryden brought out a play on the last of the Mogul emperors, *Aurangzebe*. After him and his great successor, Pope, as the classical tradition waned, the early romantic poets of the late eighteenth century, tired of classics, sent out their imaginations to fresh woods and new pastures, among which the auriferous East was also sought out. Thomson in his *Winter* spoke of the " golden coast of rich Cathay " as the haunt of busy caravans plying their trade through snowy deserts, while Cowper in *The Task* censured the London millionaires for having servilely overgorged their purses with the wealth of Indian provinces. But during these ages, owing partly to the lack of proper intercourse between East and West, and partly to the monopolization of the English Parnassus by Greek and Latin literatures, the study of the East was rudimentary and partial. Fantastic tales were current about it and therefore vagueness and uncertainty prevailed.

The Romantic Period—

With the triumph of the romantic wave, however, and the establishment of trade relations between England and the oriental countries, the former insularity of the English poets was, to some extent, conquered, and Eastern stories came to play a rôle in English poetry along with classical legends. In some instances, as will be seen hereafter, they became a formidable rival of their European

compeers and assumed an importance unforeseen in the annals of literature.

Southey—

The process begins with Southey. Even before Byron and Moore, he annexed the East as a province of romantic poetry; and though the English audience, for some time, looked askance at his novel efforts, he stuck fast to his scheme, formulated early in life, and produced his *Thalaba* and *Kehama* in spite of them. In *Thalaba, the Destroyer*, he treats of Arab life in its various phases and allows a liberal latitude to Muslim mythology. It is a tale of an Arab orphan, whose father is murdered by a race of sorcerers and whose mother is recently dead, being brought up in the tent of a neighbour and subsequently avenging his father's murder by destroying the entire seminary of the sorcerer-infidels after a series of dauntless adventures. He introduces a romantic element in the loves of Oneiza, the neighbour's daughter, and Thalaba, but soon after their marriage, which takes place accidentally in the course of the latter's adventures, the lovers are divided by the premature demise of Oneiza. The story is full of supernatural events, and at every step the power of talisman, magic, necromancy, sorcery, and divine intervention, is brought to our sight. Thalaba himself is a delegated destroyer, singled out by Providence for this heroic enterprise and his success is due not so much to his personal character as to the ever-attending forces of magic at his command. The sorcerers with whom he has to deal are, likewise, armed with miraculous powers and can turn a parched waste into a beautiful valley at their will. They are inhabitants of magic caverns under the roots of the sea. Yet in the midst of all these marvels of Eastern supernaturalism, Southey has given us scenes from the nomadic life of the Arabian desert, which do credit to his observation and vivid

imagination. Describing Thalaba's early life in the tent of his foster-father, he says—

"Domestic peace and comfort are within.
Under the common shelter, on dry sand,
The quiet camels ruminate their food;
The lengthening cord from Moath falls,
As patiently the Old Man
Entwines the strong palm-fibres; by the hearth
The Damsel shakes the coffee-grains,
That with warm fragrance fill the tent;
And while, with dexterous fingers, Thalaba
Shapes the green basket, haply at his feet
Her favourite kidling gnaws the twig,
Forgiven plunderer, for Oneiza's sake."

This is how he describes their daily round of evening life—

"'Tis the cool evening hour:
The Tamarind from the dew
Sheathes its young fruit, yet green.
Before their tent the mat is spread;
The Old Man's solemn voice
Intones the holy book.

. . . .

Their Father is their Priest,
The Stars of Heaven their point of Prayer,
And the blue Firmament
The glorious Temple, where they feel
The present Deity."

But the mythological part of this life claims Southey's special attention. In fact, the action begins with a magnificent description of Shaddad's Palace or Bagh-i-Irem, and, as the story progresses, embraces a very large portion of Mohammedan mythology. The legend of Leileth-ul-Cadr, the night when prayers are believed to be most effectual, the story of Zohak's serpents, which kept constantly gnawing at the tyrant's shoulders, the fable of Zaccoum or the tree of Hell—all come under the poet's

ken at proper occasions; while the entire story illustrates the power of talismans and amulets, which are still prevalent among orthodox Mohammedan families.

In the *Curse of Kehama*, Southey turns to the religion of the Hindus for the theme of his poem. The mythological element, as with its predecessor, forms the chief feature of the narrative, although it is skilfully subordinated to the plot. It is the story of a tyrannous Hindu monarch, Kehama, who has snatched immense power from the gods by his "yags" and sacrifices. In response to the spirit of his dead son, who had been murdered by Ladurlad for attempting to violate his daughter, Kailyal, he pronounces a curse on the poor man, the terms of which, besides prescribing a state of perpetual mental agony, include the denial of every facility of life to him,—water, air, food and the like,—and an injunction to Death to shun his body. His sway being unlimited, extending as it does over the animate and inanimate world, his curse is readily understood, and water, air, food, Death itself, scrupulously keep themselves away from him. He attempts to die but the "fell sergeant" would not touch his person. Thus, together with Kailyal, he passes his days in perpetual misery and tribulation, suffering exceedingly at the hands of Kehama, and there seems to be no hope of deliverance. The monarch, in the meanwhile, goes on performing "yag" after "yag" adding to his power till he has complete sovereignty over Earth, Heaven, and Hell and threatens to oust Seeva himself from his throne. Desperate in his sufferings yet strong in his faith, Ladurlad goes to Heaven and prays to Seeva to redress the wrongs under which mother Earth is groaning. The Almighty promises revenge, and when Kehama after conquering the entire universe goes to Heaven to demand the Amreeta Cup as a token of unchallenged authority, the inevitable nemesis of fate follows. He is given the cup and as he drinks its contents, which

were variable according to the character of the drinker, he receives poison instead of nectar, and, after his death, takes his place by the side of the doomed under the throne of Seeva.

It would appear, therefore, that the story, besides being a collection of ancient Hindu legends carefully woven together, is also a storehouse of Indian supernaturalism. It probes into the mysteries of Heaven and Hell, and a very large part of the action takes place in regions like Mount Meru and Swerga, where human frailties are superseded by supernatural powers. The gods themselves are easily accessible as in the golden age of the Hindus, or "satyuga," and play their part side by side with the mortals. The poem, throughout, illustrates the ancient Hindu belief in the power of curses, and the efficacy of prayers, penances, and sacrifices. Kehama's "yags" and sacrifices are rewarded with boons or "vardans" from the gods, among which is one conferring the power to curse. It is as a result of these that he works havoc in the universe and defies the Almighty himself. The atmosphere of the narrative is, therefore, necessarily religious. As a counterpart to Kehama's defiant character, he gives us the beautiful sketch of Ladurlad, who typifies in himself the highest virtues of a proverbial Hindu devotee. Some of his greatest victories are achieved in suffering—

"O force of faith! O strength of virtuous will!
Behold him in his endless martyrdom, triumphant still!"

The Ganges, "The Holy River, the Redeeming Flood," is also introduced as a part of the supernatural. The poet has laboriously traced out its mysterious genesis, and sums up its course in the following lines:—

"And thence through many a channel dark and deep,
Their secret way the holy waters wind,
Till, rising underneath the root

Of the Tree of Life on Hemakoot,
Majestic forth they flow to purify mankind."

In an earlier part he mentions it with reference to another incident. Casyap, the warder of heavenly bowers, refusing admission to Kailyal in his sanctuary, says :—

"That must not be,
For Force and Evil then would enter here;
Ganges the holy stream which cleanseth sin,
Would flow from hence polluted in its springs,
And they who gasp upon its banks in death,
Feel no salvation."

But the supernatural, though an essential part of the story, gives place at times to realistic scenes from Hindu life. The tale begins with a funeral, and all the ceremonies connected therewith, as well as the ancient custom of "Satee" claim the poet's attention. The mention of the marriage-knot (mangal sutra) in the function, which alone of all ornaments was left on the person of the widow mounting the funeral pyre, as well as the names of the characters, suggest that the scene of action of the story is laid in Southern India. The splendour of Kehama's court is reproduced in the following lines :—

"Within the temple, on his golden throne
Reclined, Kehama lies,
Watching with steady eyes
The perfumed light that, burning bright,
Metes out the passing hours.
On either hand his eunuchs stand,
Freshening with fans of peacock-plumes the air,
Which, redolent of all rich gums and flowers,
Seems, overcharged with sweets, to stagnate there."

The ancient ceremony of "Aswamedh" or "Raisooyag," by which a king announced his intention of becoming a "chakravarti" or unchallenged monarch of the world, and for which a sacrifice of a hundred horses was essential, is

also hinted at in passing. But the most characteristically Indian is, perhaps, the description of the dwelling scene of Ladurlad when after vitiating the "Aswamedh yag" of Kehama he returns to his cottage, with the curse pursuing his steps, and notices the familiar tank, the lotus, the cattle resting their weary limbs in water, and the din of the market-day :—

"The market-flag which hoisted high,
From far and nigh,
Above yon cocoa grove is seen,
Hangs motionless amid the sultry sky.
Loud sounds the village drum; a happy crowd
Is there; Ladurlad hears their distant voices,
But with their joy no more his heart rejoices.

. . . .

The tank which fed his fields was there, and there
The large-leaved lotus on the waters flowing.
There, from the intolerable heat
The buffaloes retreat;
Only their nostrils raised to meet the air,
Amid the sheltering element they rest."

Thus, through a maze of the most extraordinary happenings, we catch glimpses of the ancient civilization of the Hindus, of their courts and palaces, cottages and shrines, religion and culture, traces of which are still available in Indian villages. The spirit of the poem, as Southey says in the Preface, is thoroughly Indian though there is nothing oriental in the style.

In his *Roderick the last of the Goths*, a story based on the Moorish conquest of Spain, the poet takes another opportunity of dealing with Mohammedan religion. As the invasion and subsequent victory of the Moors from the central point in the narrative, he gives us vivid pictures of their manners, their dress, their weapons of war, their mode of worship, their daily colloquialisms, in fact of the entire civilization of Islam as represented by its soldiers.

As the scene of action is laid in a Christian land, the two civilizations are curiously contrasted. Among the accoutrements of the conquerors, Southey spots out

> "White turbans, glittering armour, shields engrailed
> With gold, and scymitars of Syrian steel."

The Moorish chiefs lead the attack in the name of "Allah and the Prophet". This is how he gives a rendering of the Muslim ritual :—

> "Ere long the stir of occupation ceased,
> And all the murmur of the busy host
> Subsiding died away, as through the camp
> The crier from the knoll proclaimed the hour
> For prayer appointed, and with sonorous voice,
> Thrice in melodious modulation full,
> Pronounced the highest name. There is no god
> But God, he cried; there is no god but God!
> Mohammed is the Prophet of the Lord!
> Come ye to prayer! to prayer! The Lord is great!
> There is no god but God!"

An interesting feature of the story is that the renegade Spaniards, who had joined the Moorish camp, forsake their own colloquial forms of expression and speak in a Muslim manner interspersing their interlocutions with the name of "Allah" and invoking the Caliph's power at every turn of their conversation. The Muslim belief in "One God, one Chief, one Prophet and one Law" is also faithfully brought out. The fable of Humma or the phoenix, the falling of whose shadow on a man's head is believed to be a sure sign of royalty, the conception of the Houris, the nymphs of Paradise, and the heavenly existence of the Holy Prophet, are some of the Mohammedan beliefs referred to in the poem. The composition of the Moorish army is thus described :—

> "Joined in the bonds of faith
> Accurs'd, the most flagitious of mankind

> From all parts met are here; the apostate Greek,
> The vicious Syrian, and the sullen Copt,
> The Persian cruel and corrupt of soul,
> The Arabian robber, and the prowling sons
> Of Africa."

This brings us to the close of the narrative. Among shorter pieces Southey has an imitation from Persian, in which, though the style is different, the idea is essentially oriental. It is a supplication to the Almighty in which the poet, with almost an Eastern's resignation, lays before the Lord "his nothingness, his wants, his sins, and his contrition."

Wordsworth—

Wordsworth was not so punctilious in details as Southey, though his interest in the East cannot be questioned. With him the treatment assumes a variety of forms. In an early poem entitled *The Armenian Lady's Love*, he relates the story of an Armenian princess's amours with a Christian Count enslaved in her father's court, and of her proposal to escape which ultimately fructifies. The noble Count, thereupon, is so moved by her benignant suggestion that in acknowledgment of her Christian-like virtue he thanks the Almighty with the Eastern ejaculation of "Gracious Allah!" In the *Ode to Enterprise*, the East is represented as the home of adventurous exploits—

> "Thee winged Fancy took, and nursed
> On broad Euphrates' palmy shore,
> And where the mightier waters burst
> From caves of Indian mountains hoar!"

In *Peter Bell*, the arched rocks, through which Peter was driving his ass, are compared to "Hindoo temples." In the poem *Suggested by a Picture of the Bird of Paradise* he speaks of "India's spicy regions" and of the heavenly

Glendoveers (or Gandharvas) of Hindu mythology. In the *Solitary Reaper*, the East becomes a place of romantic charm: praising the symphony of her delightful song, he says:—

> "No nightingale did ever chaunt
> More welcome notes to weary bands
> Of travellers in some shady haunt
> Among Arabian sands."

It is a romance of the sort which Keats discovers in "faery lands forlorn."

In the *Prelude*, as well as the rest of his poems, the references are as varied as in the foregoing. In Book V of the *Prelude* the poet narrates his strange experiences of an "Arab phantom" in which he saw an Arab of the Bedouin tribes mounted on a camel, carrying a stone in one hand and a shell in the other. In the same book he tells us that one of his precious belongings during his university days was "a little yellow, canvas-covered book" of Arabian tales, the three remaining volumes of which he could never buy. His study of "geometric science" in Book VI, was conducted with "Indian awe and wonder." Giving a description of the motley crowd in London thoroughfares, in Book VII, he particularly makes mention of

> "the stately and slow-moving Turk,
> With freight of slippers piled beneath his arm!"

and of the

> "Moors,
> Malays, Lascars, the Tartar, the Chinese,
> And Negro Ladies in white muslin gowns.

Describing the tug of war between the royalists and the revolutionaries during the days of the French Revolution, he elucidates the whole contest in the language of an Eastern hunt—

> "They—who had come elate as Eastern hunters
> Banded beneath the Great Mogul, when he

Erewhile went forth from Agra or Lahore,
Rajahs and Omrahs in his train, intent
To drive their prey enclosed within a ring
Wide as a province, but, the signal given,
Before the point of the life-threatening spear
Narrowing itself by moments—they, rash men,
Had seen the anticipated quarry turned
Into avengers, from whose wrath they fled
In terror."

In one of his *Sonnets to National Independence and Liberty*, he reveals a satirical outlook. Like other Tories of his age, he exults in the glory of his country; but is pained at England's conservatism :—

" and, at this day,
If for Greece, Egypt, India, Africa,
Aught good were destined, thou wouldst step between.
England! all nations in this charge agree."

In another sonnet in the Duddon series, while describing the Kirk of Ulpha, the poet indulges in a little oriental imagery. He says that it is as welcome to the pilgrim's eye

" As a fruitful palm-tree towering high
O'er parched waste beside an Arab's tent;
Or the Indian tree whose branches, downward bent,
Take root again, a boundless canopy."

The last two lines, which describe the famous banyan tree of India, bear a close resemblance to Milton's description of the fig tree in *Paradise Lost*. This tree, he says,

" In Malabar or Decan spreads her arms
Branching so broad and long, that in the ground
The bended twigs take root, a pillar'd shade
High overarch't, and echoing walks between."

In the sonnet on *Imaginative Regrets* in "Ecclesiastical Sonnets," Wordsworth's imagination carries off the lamentation to Eastern climes—

> "Proud Tiber grieves, and far-off Ganges, blind
> As his own worshippers: and Nile, reclined
> Upon his monstrous urn, the farewell moan
> Renews. Through every forest, cave, and den,
> Where frauds were hatched of old, hath sorrow past—".

and also

> "Hangs o'er the Arabian Prophet's native Waste."

In *Eminent Reformers*, a sonnet in the same series, he speaks of the "Spicy shores of blest Araby."

The *Excursion* contains a beautiful allusion to a Hindu legend. In Book III, the Solitary, discussing the philosophy of human life, explains its hidden source in the following manner:—

> "as the Hindoos draw
> Their holy Ganges from a skyey fount,
> Even so deduce the stream of human life
> From seats of power divine; and hope, or trust,
> That our existence winds her stately course
> Beneath the Sun, like Ganges, to make part
> Of a living ocean; or, to sink engulfed,
> Like Niger, in impenetrable sands
> And utter darkness."

Varied, therefore, though the references are, they leave no doubt as to Wordsworth's appreciation of the East. But various motives may be assigned for their specific mention. Sometimes it is for the mystic effect, with which he tries to clothe his idea as in the *Prelude* where he speaks of the subtle "Indian awe and wonder" with which he meditated on the abstractions of geometric science; sometimes, like Keats later, to lend a charm of distance to his description as when he refers to "Caves of

Indian mountains hoar " in the *Ode to Enterprise*, or to "Arabian sands " in the *Solitary Reaper;* and sometimes, tired of the monotonous English imagery, he may be said to enjoy a holiday in Eastern lands in the train of Rajahs and Omrahs with the Great Mogul leading the hunt, or jostling with the stately and slow-moving Turk in the streets of London, or resting beneath the shade of that

> " Indian tree whose branches, downward bent,
> Take root again, a boundless canopy,"

or perhaps whiling away his time by reading Arabian tales from his " little yellow, canvas-covered book " in the *Prelude*.

But apart from his actual references to our clime, Wordsworth may even be regarded as an oriental philosopher. The strong sanctity of animal life advocated in his nature poems and his philosophy of human life, with the ever-resounding " still, sad music of humanity " bear a close resemblance to the teachings of oriental thinkers. As it has been, time and again, preached by Hindu divines, the world with him is "an unsubstantial, faery place " unfit for living, while " that blessed mood,

> " In which the burthen of the mystery,
> In which the heavy and weary weight
> Of all this unintelligible world,
> Is lightened:—that serene and blessed mood,
> In which the affections gently lead us on,—
> Until, the breath of this corporeal frame
> And even the motion of our human blood
> Almost suspended, we are laid asleep
> In body, and become a living soul:
> While with an eye made quiet by the power
> Of harmony, and the deep power of joy,
> We see into the life of things,"

is of the very essence of " yoga." And the mysterious idea, expressed in the famous passage " Our birth is but a

sleep and a forgetting" has a lurking oriental flavour, even though it is entirely Wordsworth's own or at most Plato's.

Coleridge—

With Coleridge a reaction sets in. Possessed of a metaphysical genius, soaring always in the transcendental regions of philosophy, he shows little interest in things oriental. His references to these are therefore necessarily few. Except the stately fragment of *Kubla Khan* and a solitary sonnet on *Mahomet*, "the enthusiast warrior of Mecca, who chose good from iniquity rather than evil from goodness," hardly anything else has been vouchsafed to us in this connection. But concerning the former there has often been a misunderstanding. It is in fact not so much an illustration of his interest in the East as of his metaphysical bent of mind. Though essentially an Eastern story from the name of its hero, it is hardly different from the supernatural part of the *Ancient Mariner*. It is of small significance that the vision seen by the poet was of an oriental monarch. Had he been reading some other fantastic story prior to his momentous sleep, the result in all probability would have been similar. But as it was, the sleep came at the moment when he was reading of Kubla Khan (in Purchas's *Pilgrimage*), and so, according to his habit acquired early in life, the same "thing" was reproduced in the form of a "vision." That the imagery and setting are thoroughly Eastern and quite accord with our own magic lore, is a mere matter of chance and can hardly be said to be intentional or generally illustrative of his treatment of the East.

Scott—

The same is practically true of Scott. Essentially a poet of the Celtic Border, whose sole powerful spell

consists in "old romaunts of errantry," he does not seem to find much inspiration in the sunburnt East. This probably accounts for the comparative scarcity of oriental references in his poetry. Though professing to seek his materials equally in the ancient legends of Border chivalry or fairy-folk, and "the oriental tales of Afrite fell," it does not require much observation to realise that, in spite of his scattered allusions to "Agra's silken loom" in the *Lay of the Last Minstrel* or to a few Mohammedan manners,—as to their exclamations of Alla and Mahomet and the chanting of the prayer from the mosque—in the *Vision of Don Roderick*, the East scarcely inspires his lyre. In the few instances where we catch him admiring oriental objects as in the *Bridal of Triermain* where he minutely describes the beauty of the four Eastern maidens in the magic castle of St. John, with their hue of golden glow

"That suns of Candahar bestow,"

and their nails tinged with henna in eastern pomp, one can hardly avoid the conclusion that it is only as an illustration of his fairy lore, or in furtherance of the romantic effect, that he takes the trouble to make mention of them. To him, as to his ancient predecessors like Spenser and Shakespeare, in whose time inadequate means of communication precluded a closer understanding of the East, East is a fairy land with all the charms of magic and enchantment rather than a portion of the habitable globe. Where, however, he is alive to its earthly existence, he takes care not to grow too familiar with it and, thus, keeps it intact as a nursery of romantic objects. The mention of the alluring "soft garb of Persia's loom" in Lyulph's tale in the *Bridal of Triermain* and of the "silken couch of Ind" in Fitztraver's Song in the *Lay of the Last Minstrel* may be taken as an illustration of this viewpoint. Whatever else may be said of his novels,

where he betrays a closer acquaintance with the Eastern world, in his poetry the East does not take even a fragment of that passionate form which it was later to assume in the hands of his competitor, Byron, and others of his younger contemporaries.

Byron—

To Byron more than to any other poet of his generation is due the credit of transgressing the bounds of narrow insularism of his race and popularising the East in English poetry. Although Southey had prepared the ground before him and was the first to substitute Eastern for classical legends, his voice was meek and could not be distinctly heard. But Byron bewitched the English audience and compelled them, by the magic of his voice, to hear his Eastern stories.

His *Giaour*, the first of the series, is a fragment of a Turkish tale, telling of the loves of Leila, a Turkish slave, and Giaour, a Venetian youth, of the tragic drowning of the former by her master, Hassan, for this innocent intrigue, and of the lover's subsequent embarking on a course of revenge, which culminates in the murder of the tyrant. The scene of the story is laid in Greece but the entire action takes place under Turkish auspices. It begins with the popular feast of Bairam at the end of Ramzan, the fasting month of the Mohammedans, and the descriptions—for there is hardly any action,—are carefully couched in an oriental vein. The Rose is referred to as "Sultana of the Nightingale," echoing the well-known Persian fable of the loves of "Bulbul and Gul," while the allurement of Beauty is explained with reference to an Eastern simile :—

> "As rising on its purple wing
> The insect queen of Eastern spring,

O'er emerald meadows of Kashmeer
Invites the young pursuer near,
And leads him on from flower to flower
A weary chase and wasted hour,
Then leaves him as it soars on high,
With panting heart and tearful eye:
So Beauty lures the full-grown child,
With hue as bright and wing as wild:
A chase of idle hopes and fears,
Begun in folly, closed in tears."

The charm of Leila's eyes is similarly expressed through a series of Persian fables and similes, among which is one comparing them with the dark blue eyes of the *Gazelle* or the antelope. The most remarkable point emerging from these is that they illustrate the poet's interest in oriental phraseology, even to the extent of employing a large number of Arabic and Persian words in the narrative, such as Sultana, Haram, Fakir, Dervise, Emir, Salam, Serai, Gazelle, Alla, Mufti, Franguestan, Pasha, Bishmillah, Chiaus, Amaun, Caftan, etc., etc. The list is considerably extended in his succeeding tales.

But though the employment of Eastern similes and Eastern phraseology is the prominent feature of the tale, the poet is not for that reason blind to other aspects of oriental life. Like Southey he can indulge in Muslim mythology, and the legend of Al-sirat, the fabulous bridge leading to Paradise, the miraculous story of the jewel in King Jamshed's goblet, which was supposed to reflect the entire universe to the gazer, the notion of the Houris, the nymphs of Paradise, and the legend of Monker and Neker, the guardian angels, are all exploited for local colouring. Towards the end of the story he makes references to the Mohammedan method of burying the dead, often with the epitaph in Qoran verses, to their usual pilgrimage to the Holy Shrine, to their mode of prayer,

and to the very important Qoranic injunction against wine :—

" A turban carved in coarsest stone,
A pillar with rank weeds o'ergrown,
Whereon can now be scarcely read,
The Koran verse that mourns the dead,
Point out the spot where Hassan fell
A victim in that lonely dell.
There sleeps as true an Osmanlie
As e'er at Mecca bent the knee:
As ever scorn'd forbidden wine,
Or pray'd with face towards the shrine,
In orisons resumed anew
At solemn sound of " Alla Hu!" "

In the *Bride of Abydos*, which follows next, even the little extravagance of the mythological element, noticeable in its predecessor, gives place to a faithful description of Turkish life. The very opening lines of the tale set out the East in all its romance—

" Know ye the land where the cypress and myrtle
Are emblems of deeds that are done in their clime?
Where the rage of the vulture, the love of the turtle,
Now melt into sorrow, now madden to crime!
Know ye the land of the cedar and vine,
Where the flowers ever blossom, the beams ever shine;
Where the light wings of Zephyr, oppress'd with perfume,
Wax faint o'er the gardens of Gul in her bloom;
Where the citron and olive are fairest of fruit,
And the voice of the nightingale never is mute:
Where the tints of the Earth, and the hues of the sky,
In colour though varied, in beauty may vie,
And the purple of ocean is deepest in dye;
Where the virgins are soft as the roses they twine,
And all, save the spirit of man, is divine?
'Tis the clime of the East; 'tis the land of the Sun—
Can he smile on such deeds as his children have done?
Oh! wild as the accents of lovers' farewell
Are the hearts which they bear, and the tales which they tell."

The story may be told in a few sentences. Giaffir, a Turkish Pasha, having secretly poisoned his brother, adopts his son, Selim, as an expiation for his crime. The child, ignorant of the secret, is brought up along with his daughter, Zuleika, with whom he contracts an enduring love. A little later the surprising revelation of his father's murder, coupled with the constant rebukes of his uncle, drives him to a desperate course and he elopes with her, intending to marry. But as she is betrothed to a nobleman of her father's choice and the day of her nuptials is near at hand, they are hotly pursued by Giaffir and his party, and, when discovered, a tussle ensues. Selim dies in the tussle and when all is over, Zuleika follows suit, completing the catastrophe.

The narrative is, throughout, replete with life and vigour and holds up before us in the person of Giaffir, a view of Turkish sternness. With martial blood coursing in his veins, the least indication of lightsomeness or unsoldierly behaviour is like a red rag to him and brooks his severest censure. He can rail at his nephew, who is amorously inclined, for his unmanly pursuits, and cry out like a zealous patriot—

> "Thou, who wouldst see this battlement
> By Christian cannon piecemeal rent;
> Nay, tamely view old Stambol's wall
> Before the dogs of Moscow fall,
> Nor strike one stroke for life and death
> Against the curs of Nazareth!"

He is a hardy Turk and is so truly representative of his nation that one could hardly confound him with an Arab or a Christian,—the very air around him smacks of a Turkish savour. As we proceed along the narration, we feel his stern voice resounding in our ears, and his solemn, domineering attitude appals us. We seldom catch him laughing, his usual posture being grave and stern. When

he wields his scymitar we hear its sound from afar and grow pale with fear; the loud "Ollahs!" of his slaughter sports bewilder us. He is sternly lacking in the milder human qualities, his only concern being war and bloodshed.

As a foil to his belligerent personality, Byron gives us Selim and Zuleika, who fleet their time carelessly as they did in the golden world. Their early days are spent in pastoral simplicity and when we first hear of them, they are beguiling their hours with "Mejnoun's tale or Sadi's song." Their room is perfumed over with "Persian Atar-gul" or otto of roses, and their camp is the river's valley. They are loving, self-sacrificing, and appear to be more sinned against than sinning.

In the midst of this variegated atmosphere, we also catch glimpses of haram life. While describing Zuleika's chamber, the poet says :—

> "Yes! there is light in that lone chamber,
> And o'er her silken ottoman
> Are thrown the fragrant beads of amber,
> O'er which her fairy fingers ran;
> Near these, with emerald rays beset,
> (How could she thus that gem forget?)
> Her mother's sainted amulet,
> Whereon engraved the Koorsee text,
> Could smooth this life, and win the next;
> And by her comboloio lies
> A Koran of illumined dyes;
> And many a bright emblazon'd rhyme
> By Persian scribes redeem'd from time;
> And o'er these scrolls, not oft so mute,
> Reclines her now neglected lute,
> And round her lamp of fretted gold
> Bloom flowers in urns of China's mould;
> The richest work of Iran's loom
> And Sheeraz' tribute of perfume;
> All that can eye or sense delight
> Are gather'd in that gorgeous room."

The lines leave little for comment. Byron seems to have closely followed his oriental observations in giving prominence to the amulet, the Qoran, and the scraps of Persian poetry, these being the necessary requirements of a high-bred Mohammedan maiden. As for the fashionable part of the furniture, too, he has acted with propriety. The gorgeousness of the Orient has well been brought to our notice in the "lamp of fretted gold," "urns of China's mould," "the richest work of Iran's loom" and, lastly, the "Sheeraz' perfume," which was supposed to be the finest on the Continent.

With the *Corsair* and the *Siege of Corinth*, a new chapter is added to Byron's treatment of Turkish life. He introduces scenes of battle in which the valour of the Turks, and their determination, are brought out in clear relief. In *Corsair*, a narrative of a sea fight between a gang of Greek pirates and a Turkish monarch, the vengeance cry of "Alla-il-alla!" stands out prominent. The rigid etiquette of the Turkish court is faithfully reproduced in the formal "Salam" of the slave when on the entrance of the chief of the pirate gang in the disguise of a dervise, he carries the tidings to the Pasha. The whole process is minutely described by Byron in the following lines:—

> "With cautious reverence from the outer gate
> Slow stalks the slave, whose office there to wait,
> Bows his bent head, his hand salutes the floor,
> Ere yet his tongue the trusted tidings bore."

The *Siege of Corinth* narrates the story of a siege in which all the horrors of carnage and bloodshed are brought to our sight. The Turks are besieging Corinth, a Venetian city, assisted by Alp, an exile from Venice, now turned a renegade. Besides the gratification of his passion for revenge, Alp has yet another axe to grind. He is in love with Francesca, daughter of the Corinthian

governor, whom he expects to marry in triumph. But before the next and the fiercest assault is carried out, Francesca comes to him and requests him to renounce the Islamic faith and take her hand as a reward. Alp declines, and the next morning the whole city is devastated, Minotti, the governor, alone surviving. He takes his stand in a church, now turned into a magazine store, and fights from within. The Turks however advance and as they are on the point of desecrating the sacrificial vessel, Minotti's torch accidentally strikes against the magazine and the whole host, the victors as well as the Venetians, are blown to atoms.

It is significant that, as in the *Corsair*, the Turkish hordes when marching under the command of their vizier, raise their war-cry with "Alla Hu!" Their number is alarming, and the movement of their troops is singularly indicative of their national character :—

> "On Cithaeron's ridge appears
> The gleam of twice ten thousand spears;
> And downward to the Isthmian plain,
> From shore to shore of either main,
> The tent is pitched, the crescent shines
> Along the Muslims' leaguering lines;
> And the dusk Spahi's bands advance
> Beneath each bearded pacha's glance;
> And far and wide as eye can reach
> The turban'd cohorts throng the beach;
> And there the Arab's camel kneels,
> And there his steed the Tartar wheels:
> The Turcoman hath left his herd,
> The sabre round his loins to gird:"

There is a passing reference to "the Muezzin's voice" from the mosque at the unearthly hour of midnight, but

a more detailed account of it appears in *Childe Harold*, Canto II :—

> "Hark! from the mosque the nightly solemn sound,
> The Muezzin's call doth shake the minaret,
> 'There is no god but God!—to prayer—lo! God is great!'"

A similar description, it will be remembered, occurs in Southey's *Roderick*.

With this the series of the Turkish tales ends, but observations on the various phases of Eastern life are continued in *Don Juan*. Here we get a fuller revelation, already hinted at in the *Bride of Abydos*, of the inner life of the Zenana, but it is so grossly represented that only a bare analysis of the two chief female characters of the East will satisfy our purpose. One is Haidee, a Moorish maiden who, when Don Juan is thrown upon her island, naked and unconscious, takes him to her mountain-dwelling and nurses him tenderly with oriental hospitality. Not only the name but the very spirit of her person is truly Eastern. Like a true born Islamite, she takes pity on the "naked stranger"—as Don Juan was to her in the beginning—and lavishes all her store of feminine affection upon him, an affection which not only ruins her but makes such a deep impression on the Bohemian that he does not forget her even in his most trying moments. He forgoes the secret amours of a reputed Sultana because "he has got Haidee into his head." She offers herself to die so that her cruel father might spare the life of her dearly-bought lover. Innocent, loving and self-sacrificing, she is truly a martyr in the cause of love, a cause which costs her her very life.

At her nuptials she appears in all her splendour and according to the country's custom her eye-lashes are tinged with lampblack and her nails purpled with henna. The hangings of her room are inscribed with "soft Persian

sentences in lilac letters " and its floor spread over with " Indian mats and Persian carpets." The entertainments provided at the nuptial feast are peculiarly eastern :—

> " Afar, a dwarf buffoon stood telling tales
> To a sedate grey circle of old smokers,
> Of secret treasures found in hidden vales,
> Of wonderful replies from Arab jokers."

The fabled questions and repartees of Akbar and Birbal give us a clue to the diversion described by Byron in the last line. The eastern counterpart of the wastern custom of telling stories by the hearth on dreary winter evenings is furnished by the practice in Eastern countries, specially India, of telling tales at bedtime which are usually of the type hinted above. The pithy stories of magic ladies transformed into lords, and tales of linguistic jugglery, are still the chief stock-in-trade of village story-tellers here.

The other female character is Sultana Gulbeyaz, to whom Don Juan is sold as a slave. At her bidding, with a view to avoid suspicion, he is introduced into her apartments in the guise of a lady, but the secret being discovered by one of her maids-of-honour, the disappointed Queen has to get rid of him immediately. Her beauty and wiles are characteristically oriental. Not being allowed the freedom of open air by custom, she has her own secret modes of pleasure in the haram. She instantly falls in love with Don Juan and to gratify her lustful passion she has, in her employ, a eunuch, who is as artful as her lust would require. Aided by this eunuch attendant, she can hoodwink the simple Pasha a hundred times over, but in her intrigues with Don Juan, in spite of the strictest possible precaution, she is outwitted by a trifling mistake which she takes the earliest opportunity to rectify; and though vanquished in her design, she is supreme as before and the easy-going Pasha is, for all we know, never able to detect the amorous

trespasses of his vagrant wife. She is beautiful, cunning, reserved, and far-seeing and rules the Pasha entirely,—a Cleopatra in her own limited circle.

As a critic of Turkish life, therefore, Byron holds a unique position in English poetry. But his imagination sought other climes too; and now and then we come across references to our own land. Besides the already mentioned "Indian mats" with which Haidee's boudoir was carpeted, Don Juan's captive companion at Constantinople is supplied with a shawl, "whose folds in Cashmire had been nurst." In the *Ode to Napoleon Buonaparte*, the great general is compared to Timour of Indian history; and in the *Monody on the Death of Sheridan*, the poet mourns the death of his friend with reference to his services to India:—

"When the loud cry of trampled Hindostan
Arose to Heaven in her appeal from man,
His was the thunder, his the avenging rod,
The wrath—the delegated voice of God!"

His imagination, therefore, has a free scope and he is a cosmopolitan in his treatment of the East as in the entire range of his poetry. But of the Turkish world, undoubtedly, he is the sole accredited representative.

Shelley—

With Shelley, however, the Byronic fervour dies down, and a more general treatment is substituted instead. The first indications of his interest in the East appear in *Queen Mab*, where, referring to the variety of names and attributes, ascribed to God in different countries, he makes mention of Eastern gods and teachers of religion, such as Seeva, Buddh, Foh, and Jehovah. He expresses his indignation at the hypocrisy of the "Brahmins," of every country singing hymns to their fanciful gods, while the poorer people suffer under the yoke of misery and poverty. In *Alastor* the wandering poet is tended affectionately by

an Arab maiden, " who brought his food, her daily portion from her father's tent, and spread her matting for his couch," but she appears to be more a figment of his imagination than a maiden of the Bedouin tribes. She has no national characteristics and is hardly different from her sisters in Europe. She is cosmopolitan like his own imagination, and does not seem to resent the poet's sudden departure, who, in the meanwhile,

> " wandering on, through Arabie
> And Persia, and the wild Carmanian waste,
> And o'er the aerial mountains which pour down
> Indus and Oxus from their icy caves,
> In joy and exultation held his way;
> Till in the vale of Cashmire, far within
> Its loneliest dell, where odorous plants entwine
> Beneath the hollow rocks a natural bower,
> Beside a sparkling rivulet he stretched
> His languid limbs."

It is difficult to locate the vale of Cashmire with its hollow rocks and a natural bower of entwining plants, but perhaps it is a valley of his own country.

The *Revolt of Islam* is, similarly, a story of an imaginary revolution. Though titled as an Eastern tale and though its events are supposed to happen in the realm of a despotic monarch on the Asian Continent, it is only an abstract sermon on liberty and universal brotherhood, and is a typical illustration of Shelley's creed of revolutionary idealism. It is a tale of a brother and a sister, each imbued with the socialistic spirit of liberty and fraternity, preaching their ideals to their fellow countrymen, who happen to be ruled by a despot, and reaping the fruits of their arduous labour in a mighty revolution which culminates in the overthrow of the tyrant. But the fallen monarch, gathering strength, musters his shattered forces and renews hostilities which spell disaster to the revolutionary

reformers, who are ultimately captured and burnt alive, though the flames only serve them as flowers and they find themselves resting along the brink of a transparent lake, enjoying perpetual bliss. The events narrated are fantastic beyong belief and do not have the remotest charm of an oriental dreamland. Nor is its earthly side, too, at all Eastern; only the list of the great religious teachers of the East, which was begun in "Queen Mab," is a little extended: this time it includes Oromaze, Mahomet, Buddh, Zerdusht, Brahm and Foh. The poet is, in fact, so much preoccupied with the ever-haunting idea of reform, and the humanitarian utility of the revolution, that he hardly seems to be aware of its oriental background.

But the deficiency is made up in another way. While the story illustrates elaborately thc dreamy and rebellious side of his character, it betrays also his close affinity with Eastern thinkers. To make life sweeter and happier through what appears to be a sort of strict religious discipline, through truth and non-violence, suffering and self-sacrifice, offering love for hate, without malice even for the tyrant who tortures,—this is what Laon and Cythna, the brother and the sister of the story, have dedicated their lives for, spurning the flimsiest enjoyment for themselves and living an austerely simple life like Eastern "yogees." The revolution is conducted strictly on the lines of "ahimsa" and love, though the end hardly seems to justify the means. The oriental idea of chivalric truth is represented in the person of Laon who boldly surrenders himself to be flayed alive, after wresting a solemn promise from the tyrant that Cythna will be forgiven and sent to America. But though in contravention of the promise, Cythna is also included in the massacre, for which she shows an eagerness only to be equalled by her brother's, their greatest victory of love is achieved in falling. They appear to have brought their doctrines from some Eastern fount.

In *Rosalind and Helen* the cloud-land gives place to mother Earth. The poet makes an out-of-the-way reference to the ancient Hindu custom of "Satee." Says Rosalind, refuting the charge of falsehood laid on her in her husband's will :--

> "In truth, the Indian on the pyre
> Of her dead husband, half consumed,
> As well might there be false, as I
> To those abhorred embraces doomed,
> Far worse than fire's brief agony."

The drama of *Hellas*, though not falling strictly within the purview of this paper, may yet be considered from the author's designating it, and justly, as a lyrical dialogue. It is only here that Shelley may be said to make the nearest approach to Byron in his representation of oriental life. Like so many tales of his elder contemporary, the drama concerns itself with the tug of war between Greece and Turkey and celebrates the liberty of the former from the latter's oppression. The story is simple and may be dismissed in a few words. Mahmud, a Turkish monarch, is sleeping in his bed-room at Constantinople when, apparently, a fierce dream awakens him. Instantly he is surrounded by his advisers and lieutenants, who inform him of the fate of his battle with the Greeks. The news is so startling that henceforth he knows no rest, while the Greek revolt, as time proceeds, is successfully carried out confirming his worst suspicions.

Like Byron, Shelley's sympathies are totally with the Greeks. He has skilfully depicted the feelings of anger and dejection aroused in the Turkish Pasha as the constant tidings of the defeat of his army are brought to him,--so much so that he begins to suspect his chief adviser, Hassan, who gives him the requisite information, of having a "Greek heart." And, he can do nothing else; the prospect before him is totally dark and does not hold out any hope

of redress. Man after man brings in the news of defeat, while,

> "A Dervise, learned in the Koran, preaches
> That it is written how the sins of Islam,
> Must raise up a destroyer even now."

The poor Pasha grins his teeth and subdues his sighs. Having regard to his Eastern descent, of which pomp and grandeur are a proverbial concomitant, Shelley has faithfully reproduced the splendour of his sleeping couch, with an Indian slave lulling him to sleep. As in Southey, the Muslim belief in "one God, one King, one Hope, one Law" is more than once hinted. Says **Hassan**:—

> "The lamp of our dominion still rides high;
> One God is God—Mahomet is his Prophet."

The war-cry of the Turkish army is, similarly, "Allah-illa-Allah!" It will be seen, therefore, that it is here alone that he comes down to realities; he has, however, no leisure to revel in oriental legends.

In the *Triumph of Life* he reverts unconsciously to his original position. He makes a sweeping allusion to "some Indian isle" and speaks of "a flock of vampire-bats" hovering over it to indicate the inexplicable idea of mysterious phantoms dancing over earth and sky and filling the grove with dense shadows. It appears that as India, for a long time in the past, was considered by westerners to be a land of mysteries, Shelley thought it best to explain away the mysterious shadows, conjured up by his imagination, by associating them with like appearances on this "dark continent." There seems to be hardly any other significance of this strange simile.

The *Sensitive Plant* contains a reference to "a basket of Indian Woof" and to "Indian plants," which were

> "of scent and hue
> The sweetest that ever were fed on dew."

The *Lines to an Indian Air* are particularly interesting. The subtle " Champak odours " that fail " like sweet thoughts in a dream " do not only express the poet's idea of the sweet smell of Champa flower, but convey in general the westerner's impression of the heavily perfumed atmosphere of the Orient. Sometimes the gale wafted to his imagination is incense-bearing and odorous, " tasting of flora and the country-green," sometimes laden with " Persian atar-gul," " oppressed with perfume"—cloying the sense—as in Byron, sometimes smacking of spices as in " India's spicy regions," or on the " blest shores of Araby " which charmed Wordsworth's lyre, sometimes " redolent of rich gums and flowers, overcharged with sweets " as in Southey, but it is always subtle, indefinable, puzzling. He does not know what it is like, but he smells it audibly. It makes the East more glamorous, charming, romantic,—in a word, more Eastern.

Keats—

This last attribute becomes closely associated with our clime as we pass on to Shelley's younger contemporary, Keats. As his fiery imagination disdained to be critical, the references in him do not so much treat of Eastern *life* with the hackneyed details of men, women, and manners, as of Eastern *romance*. Everything is presented through a haze of romantic splendour. In *Endymion*, the " Ganges and its pleasant fields " are alluring. The Indian maiden herself is transplanted to Earth from her " magic casements " in the starry regions : she happens to be the moon-goddess, Cynthia, in disguise. She is therefore no more an Indian maiden, but a " Swan of Ganges," " my Indian bliss," " my sweetest Indian;" we have never seen her like in our country. The heaven of Great Brahma is " mystic," while the pompous train of young Bacchus is greeted by the Kings of Inde with a shower of " jewel-sceptres " and

"pearled hail,"— their wealth seems to be immeasurable. In Book II there is an allusion to Alexander's invasion of India but it does not so much illustrate Keats's interest in Indian history as his repugnance to it. The very lines say—

> "What care, though striding Alexander past
> The Indus with his Macedonian numbers?"

To him a charming oriental imagery is much more enduring than the ephemeral glory of great monarchs whose names, as he said of his own, "are writ in water."

The same viewpoint is illustrated in his succeeding poems. He refers to Eastern objects not so much for their intrinsic worth as for the romantic glamour, they lend to his descriptions. In *Hyperion*, while the fallen gods are holding council, Asia's imagination soars to

> "Palm-shaded temples, and high rival fanes,
> By Oxus or in Ganges' sacred isles."

In *Hyperion, a Vision*, he speaks of the fumes of "Asian poppy," though in this case they do not compare favourably with that transparent juice, of which he had already had a sip and had left the world unknown. In the *Eve of St. Agnes*, among the delicacies at Porphyro's table in Madeline's bedchamber are

> "Manna and dates, in argosy transferr'd
> From Fez; and spiced dainties, every one,
> From silken Samarcand to cedar'd Lebanon."

In the *Pot of Basil*, the poet is enamoured of the "warm Indian clove" and "precious flowers plucked in Araby," while among more subtle references, we have the revelation of the ghost moving Isabella

> "like a lance
> Waking an Indian from his cloudy hall
> With cruel pierce,"

and the gradual process of her withering

> "like a palm
> Cut by an Indian for its juicy balm."

It will not, therefore, be wrong to assert that Keats does not probe into the mysteries of the Oriental world in the manner of Southey and Byron. Like Shakespeare, he treats of it more in the nature of a poetic fancy than as a sincere attempt to unlock its secrets or understand its psychology. Wherever he refers to it,—to its cities and men, to its flora and fauna, to its rivers, mountains, and glades.,—it is always to lend an enchantment, a distant glamour to his "sensuous" description, to produce an effect, rather than to admire its beauty. With a Hellenic taste and a genius steeped in classical legends, he could not be expected to send out his imagination to its sunny plains or its gorgeous palaces. It may, therefore, be said of him, with perfect justification, that the East has only "clapped him over the shoulder" and not made a deep impression upon his mind.

Moore—

Of all the writings of the English poets on the East. *Lalla Rookh*, perhaps, is the only poem where the author may be easily mistaken for a native of the East. Seldom has the Oriental world seen its features so unmistakably reflected in the writings of a western poet as in this famous masterpiece of Moore's. The poet has, without any pretensions, shown that he is as fluently conversant with the Hindu mythology as with the Muslim and as much with the Zoroastrian as with his own. From the "Camalata of Indra's heaven" and "the pranks of Crishna" we hear him talking in one breath of the loves of Wamak and Ezra, the fairy romance of the white-haired Zal, and the popular myths of the Fire-worshippers. Nor does he forget to make

mention of "the copious flow of Ferdosi, the sweetness of Hafiz, the sententious march of Sadi" with the ethereal music of Tan-sein. From the barest outlines to the most intricate details, Moore has one unbroken line of poetic splendour.

The story may be retold in a few sentences. Lalla Rookh, the youngest daughter of Emperor Aurangzeb, is betrothed to Aliris, the Crown Prince of Bucharia, who ascends throne at the abdication of his father. As the nuptials are proposed to be celebrated at Kashmire, the bridal procession leaves the imperial city of Delhi in a right royal manner and proceeds along the road to Kashmire. Among the many attendants, sent by the young King of Bucharia to accompany his bride, is Feramorz, a poet, who undertakes to recite poems to beguile the tedium of the long journey. As the days pass on in this manner, Lalla Rookh falls deeply in love with the young poet, who is equally responsive. But as the procession is nearing the end of its journey, the poet leaves her, much to her distress, while reluctantly she makes preparations for the coming nuptials. On the appointed day she is conveyed to the grand saloon where the King rises to meet her. "But scarcely had he time to take her hand in his when she screamed with surprise and fainted at his feet. It was Feramorz himself that stood before her!—Feramorz was, himself, the Sovereign of Bucharia who in this disguise had accompanied his young bride from Delhi, and having won her love as an humble minstrel, now amply deserved to enjoy it as a king."

The plot, therefore, is not of an intricate kind, but the personages enacting the drama are true Eastern potentates with a lifeblood at once sunny and magnificent. First, there is Lalla Rookh herself, a tender, graceful lady, "described by the poets of her time as more beautiful than Leila, Shirine, Dewilde, or any of those heroines whose

names and loves embellish the songs of Persia and Hindostan." Daughter of Aurangzeb, she hardly betrays any lineal connection with that great Mogul, but shows much, on the other hand, of the fine qualities of grace and kindness. She is forgiving as Eastern maidens generally are, and her one absorbing passion is love. But it is strictly regulated and is seldom allowed to exceed the bounds of decorum and decency. When she first discovers that she is in love with Feramorz, the young poet sent to beguile her journey, she shuts herself up and even allows herself the discourtesy of restricting his admission, so that the heart she has to offer to the king of Bucharia, though cold and broken, may not at least be impure. "To have strayed so far into the dangerous labyrinth," she thinks, "is wrong, but to linger in it, while the clue is yet in her hand, would be criminal." For a lady of her character, therefore, there can be hardly any praise that is not deserved and hardly any reward that is not well merited.

We come, then, to the poet—or, the so-called poet—whose recitals form the bulk of the narrative. Though—to use the words of the ever-amusing Fadladeen—with a style not so fluent as that of Ferdosi or sweet as that of Hafiz or rapid as that of Sadi, his manner of reciting the stories is unique, and the chords of his favourite guitar reverberate constantly in our ears as we proceed along the narration. For all we know, Moore himself is his own Feramorz and may like him be said to be "much celebrated for his manner of reciting the stories of the East." What, for instance, can be a better compliment to his art than the way in which he gives a description of "that sweet Indian land,

> Whose air is balm; whose ocean spreads
> O'er coral rocks, and amber beds;
> Whose mountains, pregnant by the beam
> Of the warm sun, with diamonds teem;

> Whose rivulets are like rich brides,
> Lovely, with gold beneath their tides;
> Whose sandal groves and bow'rs of spice
> Might be a Peri's Paradise!"

or of that "Paradise of the Indies," Cashmere—

> "Who has not heard of the Vale of Cashmere,
> With its roses the brightest that earth ever gave,
> Its temples and grottos, and fountains as clear
> As the love-lighted eyes that hang over their wave?
> Oh! to see it at sunset,—when warm o'er the Lake
> Its splendour at parting a summer-eve throws,
> Like a bride, full of blushes, when ling'ring to take
> A last look of her mirror at night ere she goes!—
> When the shrines through the foliage are gleaming half-shown,
> And each hallows the hour by some rites of its own.
> Here the music of pray'r from a minaret swells,
> Here the Magian his urn, full of perfume, is swinging,
> And here, at the altar, a zone of sweet bells
> Round the waist of some fair Indian dancer is ringing."

From the poet we pass on to the critic, Fadladeen, by far the most charming of personalities in the whole procession. Like Polonius, he is a judge of everything—"from the pencilling of a Circassian's eyelids to the deepest questions of science and literature, and his political conduct and opinions are founded upon that line of Sadi—' Should the Prince at noon-day say, It is night, declare that you behold the moon and stars'." His chief mission in the story is to scrutinize Feramorz's verses and his judgment may, in practically all cases, be safely anticipated as one of trenchant criticism. Inexorable critic as he is, his judgements are always magisterially delivered. But the capricious nature of his character denies him the favour of the ladies, and when he is surveying the beauties—or rather, the defects—of Feramorz's "Veiled Prophet of Khorassan," just recited, in one of his loftiest moods of criticism, he

finds, to his utter discomfiture, that most of his audience are asleep and so he cuts down his animadversions with the triumphant belief that he has, for the hundred and fiftieth time in his life, extinguished a poet. He can hardly find good in Feramorz's utterances and when he is tired of his nonsense, he finds relief in writing a note to the King of Bucharia prescribing a " chabuk " for his back instead of torturing him with the minor details of criticism. It is amusing to look at Fadladeen with his critical eyebrows elevated and his faculties refreshed with a dose of opium, and one is, for once, tempted to go along with him and share with him his onerous duties as Grand Chamberlain of the Haram.

In matters of religion, too, he has very decisive opinions, and the least reference to the Ghebers, or infidels, sets him off his balance. At the mention of the Fire-worshippers, unable to do anything, the poor Chamberlain sits in unspeakable disappointment and expects treason and abomination in every line that Feramorz is going to recite,—his agony at the time is simply heart-rending. He can never make up his mind as to the merits of a poet unless he knows definitely whether he is a " shia " or a " sunni ", and like a pious Mussalman takes delight in killing the mimic lizards when he reaches the tomb of Hussun Abdaul.

In discharging his duties as the Great Chamberlain, he is very strict and unless any matter receives the stamp of his authority he would not let it pass by without duly informing the King. It is by his special command that Feramorz is forthwith introduced into the haram, and we well may, for this reason, forgive him the dignity with which, borne as he is immediately after the Princess, he considers himself to be not the least important personage of the bridal procession. His opinions, for whatever they are worth, always have the greatest influence over the various tastes of the day, and when he has

delivered his judgment on Feramorz's verses the ladies begin to suspect that they should not, after all, be enamoured of the poet, since there must be much good sense in what Fadladeen has said from its having set them all so soundly to sleep. It is not surprising, therefore, that he should have set the fashion for the young gallants of the Mogul Court and, what is more, acquired a reputation for his omniscience and sagacity! The younger men and women of the marriage party flock to him to get their difficulties solved and even though he may not be able to explain them a jot, he is never vanquished. Like the pedagogue of the *Deserted Village* he goes on arguing and sets the greatest of experts on defiance. We really feel the utmost sympathy for him when we learn that the cooks do not obey him and are obstinate in putting the pepper of Canara into his dishes instead of the cinnamon of Serendib, and that his Koran is misplaced and he has to go without it for three whole days! But as we are helpless, we simply curse the cooks and the Koran-bearer and proceed along our narrative. When the procession reaches its destination and with the nuptials of Lalla Rookh the secret is disclosed that it was the Prince himself who had all along been accompanying his bride in the guise of a humble minstrel, the plight of poor Fadladeen is simply pitiable. He retracts all his criticisms which, he says, were instantly delivered, and comes to have an unbounded admiration for the King's verses; and instead of prescribing the "chabuk" for the poet,—now no longer a poet,—he would prescribe it for all those who dared to think otherwise. Therefore, for a man of his wisdom hardly any respect is too great and hardly any admiration too extravagant. Like Nick Bottom he hath simply the best wit of any aristocrat in Delhi and it would be a sad day, indeed, for the Mogul Court if his versatile genius were allowed to lie dormant. Our difficulties melt away as soon

as Maulana Fadladeen handles them, and we feel the better and happier for his presence.

After such a galaxy of truly Eastern characters it would not be easy for any critic to overestimate the oriental genius of Moore. He shows as much familiarity with Eastern scenery, manners and customs, etc., as can be expected of a native poet. His imagination, as Byron expected, has created "a warmer sun and a less clouded sky." It is from the very depth of Moore's heart that the cry comes :—

> "Blest power of sunshine!—genial Day,
> What balm, what life is in thy ray!
> To feel thee is such real bliss,
> That had the world no joy but this,
> To sit in sunshine calm and sweet,—
> It were a world too exquisite
> For man to leave it for the gloom,
> The deep, cold shadow of the tomb."

The scene of *Lalla Rookh* is laid in that beautiful Vale of Cashmere "which the Persians so justly called the Unequalled," and the Hindu temples and pagodas as well as the Muslim mosques and tombs all move before our eyes in a living pageant The flowers, birds, fountains, glades, peaks, boats—in fact, the entire landscape of that beautiful valley,—are presented to our sight as in a caravan journey. —for a moment, we ourselves seem to be moving along with the royal procession. Nor has the poet lost sight of the man-made institutions. The ancient Hindu practice of floating a burning lamp in the neighbouring river at vesper hours to pray for the safe return of friends who have gone on dangerous voyages, the worship of the monkey deity or the Hanuman, and among Muslim customs, the practice among the followers of Abbas to put on black garments, the now obsolete practice of killing lizards, and among common practices, the custom of tinging the hands with henna

paste in particular seasons, or applying lamp-black in the eyes—all are appropriately mentioned. Once, in the story of the *Paradise and the Peri* he makes reference to the invasion of Mahmud Ghazni and the brutalities that followed in its wake; and taking the historical lines

> If there be a Paradise on earth
> It is this, it is this, it is this,

he has applied them to the scene of Jehangir's revelry in the *Story of Sultana Nourmahal*. From all these it is evident that the poet is truly enamoured of the "gorgeous East" and has done full justice to its men and manners. It was not surprising, therefore, that Moore's friend, Luttrell, congratulated him on Lalla Rookh's being sung "in the streets of Ispahan": what is at first sight rather remarkable, as Godley says, is that it should have been sung in the streets of London—much more, that "Dear Lalla Rookh" should have delighted generations of English schoolgirls.

Moore's next contribution to the treatment of the East after this brilliant rhapsody is *The Loves of the Angels*, in which three fallen angels, all apparently belonging to the Muslim fold, are of an evening conversing by a hillside, recanting the sad stories of their loves. There is, however, nothing peculiarly oriental about their tales save that they contain frequent allusions to Mohammedan mythology and are occasionally punctuated with emphatic "Allahs!" Once in the narrative he makes a striking reference to the legendary fidelity of Eastern slaves: describing the first encounter of the third angel with his sweetheart, he says—

> "He saw, upon the golden sand
> Of the sea-shore, a maiden stand,
> Before whose feet the expiring waves
> Flung their last offering with a sigh—
> As, in the East, exhausted slaves
> Lay down the far-brought gift, and die—"

In the song of *The East Indian,* he gives, by the way, a short description of the Eastern clime—

> "The fields where she was straying
> Are blest with endless light,
> With zephyrs always playing
> Through gardens always bright."

It will be recalled that Byron makes a similar reference in the opening lines of the *Bride of Abydos.*

In *A Dream of Hindostan,* a short satirical piece, the poet satirizes the Hindu creed of vegetarianism. In a dream he is bewitched away

> "To a goodly city in Hindostan—
> A city, where he, who dares to dine
> On aught but rice, is deem'd a sinner;
> Where sheep and kine are held divine,
> And, accordingly—never drest for dinner."

Among other minor pieces on the East, Moore has two ballads, entitled *The Young Indian Maid* and *The Indian Boat* but they do not show any first-hand understanding of the East.

Campbell—

We pass on to Campbell. After Moore and Southey, he is the third poet of his generation to celebrate the "monstrous" Hindu mythology into English verse. In *The Pleasures of Hope* he refers to the well-known Hindu belief in the periodical descent of "avatars" or incarnations of deity, and alludes to several gods and goddesses of the Hindu mythology, such as Seriswatti, the Goddess of Learning, corresponding to the Roman Minerva, Camdeo, the Indian Cupid, Ganesh, Brama, etc. He speaks of Hindus as "Brama's children." Like Southey

and Shelley, he also takes note of the now defunct custom of "Satee"—

> "The widowed Indian, when her lord expires,
> Mounts the dread pile, and braves the funeral fires!"

But he rises to a high pitch of pathos when referring to the historic invasion of Timour and the atrocities that followed:—

> "Ye orient realms, where Ganges' waters run!
> Prolific fields! dominions of the sun!
> How long your tribes have trembled and obeyed!
> How long was Timour's iron sceptre swayed!
> Whose marshalled hosts, the lions of the plain,
> From Scythia's northern mountains to the main,
> Raged o'er your plundered shrines and altars bare,
> With blazing torch and gory scimitar,—
> Stunned with the cries of death each gentle gale,
> And bathed in blood the verdure of the vale!
> Yet could no pangs the immortal spirit tame,
> When Brama's children perished for his name;
> The martyr smiled beneath avenging power,
> And braved the tyrant in his torturing hour."

In the *Ode to Winter* he speaks of "India's citron-covered isles" as the haunt of "Rosy Summer," and in the poem entitled "On getting the portrait of a six-year old female child," he hints at the proverbial fame of Cashmere shawls.

But it is not the Indian soil alone which engages his attention. He allows a wider range to his imagination and from the farthest corner of the East in China he may be seen travelling through Persia, Arabia, Turkey, Egypt to as far as the Moorish wasteland in Algiers. In *The*

Power of Russia, while lamenting the fall of Poland at the hands of Russia, he takes stock of its (Russia's) vast martial resources, and exclaims:—

> "Eighth sharer of the inhabitable sphere,
> Whom Persia bows to, China ill confines,
> And India's homage waits, when Albion's star declines!"

In the ballad of *The Turkish Lady* he sings of the love of an Eastern lady for an English knight and of their secret escape to Rhodes. In the *Song of the Greeks* he represents the Greeks as rising up in revolt against Turkish sovereignty and speaks contemptuously of the Turks as "Mahomet's slaves." In *The Battle of Navarino*, the same theme is continued. He celebrates the victory of Greece and its allies against Turkey and Egypt and, as in the previous poem, makes a contemptuous reference to "Mussalman slaves" and the dimmed glory of the Saracen's moon. Like Byron and Shelley his sympathies are with the fallen Greece.

In the fragment on the *Dead Eagle*, the poet, for once, indulges in a series of oriental similes. First, he compares the fallen state of the dead bird to royalty in ruins—

> "Though his eyes
> Are shut, that look undazzled on the sun,
> He was the Sultan of the sky, and earth
> Paid tribute to his eyry."

Next, contrasting the charm of his natural strength with the mock artifice of humankind, whose aerial conquest he describes as "a rash intrusion on the realms of air," he says that whereas the flight of the aeronaut lacks volition and he drifts the passive plaything of the winds, the eagle clove the adverse storm and "stopped his flight as easily as the Arab reins his steed." Finally, continuing the

royal metaphor, he traces the course of his flight through Eastern climes :—

> " Where Atlas' top looks o'er
> Zahara's desert to the equator's line—
> From thence the winged despot mark'd his prey,
> Above the encampments of the Bedouins, ere
> Their watchfires were extinct, or camels knelt
> To take their loads, or horsemen scoured the plain."

But the most remarkable references occur in the *Epistle from Algiers to Horace Smith.* Here Campbell gives very humorous descriptions of the Mussalman and of the Moorish ladies. First as to the former,

> " In his breeches of petticoat size
> You may say, as the Mussalman goes,
> That his garb is a fair compromise
> 'Twixt a kilt and a pair of small clothes."

Next follows the description of the Moorish ladies—

> " The Mooresses, shrouded in white,
> Save two holes for their eyes to give room,
> Seem like corpses in sport or in spite
> That have slily whipped out of their tomb."

It will be seen, therefore, that though the references are in fragments, everywhere they betray a close observation and a sympathetic interest. He does not content himself with the mere naming of oriental curiosities to show off a bare acquaintance, but gives you the very details themselves. He may be said to carry on the tradition of Southey and Byron far into his own age.

Leigh Hunt—

With Leigh Hunt, the treatment breaks fresh ground. Instead of feeding his imagination on scattered allusions or constructing stories on Eastern themes, he takes to versifying charming anecdotes, handed down from Persian

and other oriental literatures. They are short, pithy stories and have all the charm of an original composition.

In the story of *Sultan Mahmud*, the poet narrates an interesting anecdote of a Muslim monarch administering justice in strict accordance with Qoranic injunctions. A man comes before the Sultan complaining of the intrusion of one of his officers into his house and creating trouble. With four armed slaves, the Sultan goes to his house and orders the light to be put out. This done, and the females removed, he rounds up the offending officer and kills him after a little combat. Thereafter he sends for light, scrutinizes the lineaments of the slain man, and bows to God in gratefulness. On being asked the reason of his command about the light and his subsequent prayer to the Almighty, the Sultan replies that he had it put out so that if the offender had been his own son, his fatherly affection might not have deterred him from bringing him to book, and his kneeling down to the Sovereign Arbiter was in thankfulness for the discovery that it was not so and the slain rogue was a stranger.

The poem very well illustrates the notion of justice fabled to have been prevalent among Mohammedan Kings and Qazis in the high days of Muslim civilization. A similar story is told of an honest Mussalman king who, when accused of some crime and summoned to the court of his Qazi, went with a sword hanging under his waist, and when, after the Qazi had pronounced judgment against him, he was questioned as to his intention in carrying the sword, he replied that it was for dealing a fatal blow on the Qazi's head if, prejudiced in his favour, he had departed a jot from the divine law.

It is in the adaptation of anecdotes like these that Leigh Hunt may be said to give a new turn to the treatment of the East in English poetry. His *Abou Ben Adhem*, too, is a poem of the same type although the story in this case is

different. A pious Mohammedan chief, Abou Ben Adhem by name, when sleeping one night in his chamber sees in a dream the vision of an angel writing the names of the lovers of God in a book of gold. Questioned as to the inclusion of his name in the list, the angelic presence replies with a nod, and on his subsequent request to write it down among those who love their fellowmen, the angel writes and vanishes away. The next night it appears again and when Abou Ben Adhem is shown the compiled list, he finds, to his astonishment, that his name figures on the top.

It is the story of a miracle and illustrates, in an oriental manner, the mysterious modes of divine dispensation. It inculcates also the lesson of fellow-feeling by linking it, like so many Eastern things, with the idea of divine favour. The sudden revelation of Ben Adhem's saintly name leading all the rest, especially after the angel's announcement the previous night that it did not come within the list at all, takes the reader by surprise. Eastern gods, like Eastern kings, are whimsical: now they are irritated at an entreaty, now pleased at a rebuke; they show you favour when they list.

With these stories we have practically exhausted Leigh Hunt's stock of Eastern writings. His *Story of Rimini*, though the chief of his productions, does not, however, contain any reference to the East, except one to a troop of steeds in the bridegroom's procession whom he describes as "milk-white and Arabian bred." But this does not illustrate his usual habit. As pointed out in the beginning he delighted more in the charm of anecdotes, like the foregoing, than that yielded by any other Eastern object.

Conclusion—

We are now in a position to wind up our survey.

From what has been said it will have become clear that in their use of the Eastern material, the poets of the period under review fall into three groups:—those, who have portrayed Eastern life in all its details: in this category we include Southey, Byron and Moore in whom the oriental world has found a willing mouthpiece; those, whose range though not so penetrating and wide does yet betray a close understanding of the East, and in this class come Shelley, Campbell and Leigh Hunt; and, finally, those, whose interest is only casual: this class includes Wordsworth, Coleridge, Scott and Keats. But all were, to a greater or lesser extent, enamoured of the new clime. After the monotony of coffee-houses and clubs, and the familiar scenery of old England, here at last was a pleasant scene,—gorgeous, warm and fragrant,—in whose sandal groves and spicy bowers they found a congenial repose; whose valleys though not possessing the charm of Tempe or Arcady were, nonetheless, for ever haunted by the wings of zephyr, with flowers over-blooming and beams ever-shining; whose mountains though not rich in lyrical gifts, however, teemed with diamonds; and whose virgins though not boasting of the beauty of Helen or Isolde were yet soft as the roses they twined. Here, at last, after centuries of listening to the lyre of Orpheus, they turned to the lute of Tansein and found the music attractive

SECTION II

SANSKRIT

UNIVERSITIES OF INDIA DURING HINDU PERIOD

BY

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That the connotation and denotation of the term University was correctly understood and precisely applied in ancient India has been shewn by Mr. Sankalia in his excellent publication[1] on the analogy of Roshdall and Newman.[1] The former of these authorities has traced[2] the origin of the English term 'University' to a collection of teachers and students and the latter expanded the idea to students of every kind.[3] This expanded idea had naturally identified itself with an institution where all the arts and sciences were taught as stated by other authorities.[4] The Sanskrit term *Viśva-vidyālaya* is more significant and implies a place of learning of universal subjects. The universal character of Indian Universities is proved beyond doubt by the interchange of students and teachers in India and abroad, by the varied courses of studies and methods of examinations, and corporate life of students and teachers in the same institution for a fixed period. The advanced students of the University of Nalanda, coming from Japan, Korea, China, Tibet, Java and Sumatra, and those from Taxila, Valabhi, Conjeveram, etc., and eminent professors

[1] *The University of Nalanda* by Mr. Hasmukh D. Sankalia, M.A., LL.B., published by B. G. Paul & Co., Madras, pp. vii-xxvi, 1,259.

[2] *The Universities of Europe in the Middle Ages.*

[3] The Idea of a University.

[4] Monheism, *History*, Vol. II.

of this University visiting on invitation such distant countries as Tibet, China, Kamarupa, Suvarṇadvīpa, etc., will shew not only the popularity of the institution, but also the universal collection of teachers and students. At Nalanda there were at some time some 10,000 resident students and teachers. There were 12 colleges, 3 big libraries and some 300 rooms for the residence of the students.

From the excavation and the accounts of Hiuen Tsiang and I-Tsing it appears that the University of Nalanda consisted of several *Vihāra*, *Sanghārāma*, *Dharmagañja* and *Chaitya* buildings. There were colleges, halls, libraries, observatories, priests' chambers "the richly adorned towers and the fairy-like turrets" and other necessary and auxiliary quarters including "brilliant and magnificent chaityas" (memorials). "The whole establishment" in the words of Hiuen Tsiang, "is surrounded by a brick wall. One gate opens into the great college, from which are separated eight other halls, standing in the middle." The *Sanghārāmas* appear from the excavations to have been built in rows and were three to four storeys high. I-Tsing testifies and the excavations corroborate that there were at least eight to twelve colleges and over 300 rooms. The Tibetan accounts testify to the existence of a grand library, called *Dharmaganja*, comprising three grand buildings. One of these three buildings was known as *Ratnodadhi* and it was nine-storey high and it stocked the sacred scriptures, *Prajñāpāramitasūtra*, and the Tantric works such as *Samājaguhya*, etc. The other two were called *Ratnasāgara* and *Ratnarañjaka* containing presumably secular and other works referred to in connection with the subjects and courses of studies. The priests' chambers were distributed in all the outside courts comprising four stages which had "dragon projections and coloured eaves, the pearl-red pillars carved and ornamented, the richly adorned balus-

trades, and the roofs covered with tiles that reflected the light in a thousand shades." In an inscription Nalanda is described as "a city which mocked as it were at all the cities of the Kings." His biographer (Hwui Li) elaborates Hiuen Tsiang's statement: "Students in Nalanda study the great vehicle and also (the works belonging to) the eighteen sects, and not only these, but even ordinary works, such as the Vedas and other books, the Hetuvāda, Śabdavidyā (phonology), Chikitsāvidyā (medicine and surgery), the Atharvaveda (dealing with magic etc.), Sāṅkhya (philosophy); besides these they thoroughly investigate the miscellaneous works." Hiuen Tsiang himself is stated to have studied at Nalanda "Yogaśāstra, Nyāya, Anusāraśāstra, Hetuvidyāśāstra (logic), Śabdavidyā and Kosha, Vibhāshā etc.," from Śīlabhadra and other professors. "Learned men from different cities," says Hiuen Tsiang, "who desire quickly to acquire a renown in discussion, come here in multitudes to settle their doubts, and the streams spread far and wide." "Thus instructed by their teachers," elucidates I-Tsing, "and instructing others they pass two or three years generally in the Nalanda monastery, in Central India or in the country of Valabhi in Western India. There eminent and accomplished men assemble in crowds, discuss possible and impossible doctrines and after being assured of the excellence of their opinion by wise-men, become far famed for their wisdom."

In this method Mr. Sankalia correctly finds an analogy of what Rashdall defines to be the University examinations followed in Europe "any process of inquiry into the candidate's fitness as well as direct tests of his scholastic attainments." That Nalanda was not merely a Buddhist institution dealing with Buddhist scripture and theology has been proved beyond doubt by the Ghossawa Inscription. Herein it is stated that Devapaladeva received and patronised "a very learned Brahmin, Vīradeva, who had come to Nalanda

after visiting many centres of learning, such as Kanishkapura, Yaśovarmmapura etc., and was afterwards elected the Head of the Sangha (i.e., the Chancellor of the University) by the assembly of the Monks (professors)." It is rightly inferred from this that 'King Devapāla was connected with the administration of the University, which, besides the profound learning of Vīradeva, must be the cause of the latter being elected the Head of the Sangha.' There appear to have been two groups of students admitted to the Nalanda University. Being a residential University, the students seeking admission had to pass an entrance examination significantly stated to have been held by the "gate-keepers." Hiuen Tsiang who was a grown up residential scholar at the University says that all the new entrants had to satisfy the authorities that they had already "studied deeply both old and new (subjects) before getting admission."

There are epigraphical and other evidences to the effect that large contributions were made to the University for its enlargement by kingly persons from Suvarṇadvīpa (Sumatra), Yavadvīpa (Java), Maloda, Tikina, the Tukharians, and a Gurjara-Pratihara King named Mahīndrapāladeva. The Universities at Taxila in the North-West, Valabhi in Kathiawad (Gujerat), Vikramasila in Bihar, and Odantapuri, Jaddala, Somapuri, and Vikramapuri in Bengal were of the type of Nalanda University which was founded in the fifth century by the Imperial Guptas and was seen in full working condition by numerous Chinese and Tibetan travellers including Hiuen Tsiang, I-Tsing and others. It lasted for nearly a thousand years and was patronised by Knig Harshavardhan of Kanauj, and the pāla Kings of Magadha. There were also big colleges at Bodh-Gaya, Sanchi, Barhut, Śrāvasti, Kauśambī, Sarnath, Mathura, Nāsika, Amarabati, Nagarjunikunda, Jagayyapeta, Kanchipura, Kaneripattana, and Madura. Dr. Barua

has shewn that there were some 84,000 smaller secondary and primary schools at the time of King Asoka.[1]

From the actual working of these educational institutions the method, aim and ideal of education in Hindu India is apparent. A satisfactory solution was found out by the then authorities of problems dealing with the types of education suitable for different groups of students, the continuous as well as continual periods of study, the training of mind, intellect, character, hands, eyes and ears, the ultimate aim and idea of education, the right type of teachers, the proper courses of study including physical exercises, sports and games, and the method of teaching and examination.[2]

Physical exercises were included in the curriculum not merely to provide diversion from serious study but with an express object of keeping the body and mind of the scholar fit. Mr. Sankalia[3] has supplied a list of games from the Chullavagga (1, 13, 2) which includes besides dancing with ladies, " games with eight pieces and ten pieces, tossing up, hopping over diagrams formed on the ground, and removing substances from a heap without shaking the remainder : games of dice and trap ball; sketching rude figures, tossing balls, blowing trumpets; having matches at ploughing with mimic ploughs; tinkling; farming, mimic, wind-mills; guessing measures; having chariot races and archery matches, shooting marbles with

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[1] Introduction to Sridhar Barua's *Bauddha-pitha.*

[2] See Dr. Barua (*ibid.*, p. ix).

[3] It is doubtful if Mr. Sankalia had direct access to all the original Brahmanical literature dealing with sports and games (see his *Nalanda University*, p. 162). The Buddhist monks like Hiuen Tsiang and I-Tsing on whose accounts of Nalanda University life he has solely based his interpretation can hardly be expected to have taken any interest in physical exercises of pre-Buddhist period.

fingers; guessing other people's thoughts and mimicking other people's acts; elephant riding, horse riding, carriage driving and swordsmanship; to run to and fro in front of horses and in front of carriages; to exhibit signs of anger, to wring hands and to wrestle. and to box with fists; and spreading out robes as a stage and inviting girls saying 'here you may dance. sister' and greeting her with applause."

An idea of the proper method of teaching can be gathered from the classification of scholars into four groups. The group known as the *Padaparama* could do no more than swallowing or getting by heart everything they read. The group known as the *Neya* was of slow understanding and had to be spoon-fed step by step in order to make them understand slowly owing to their inferior intellect and power of grasping. The group known as the *Vipaśchitajña* was of keen intellect and could follow learned lectures with a little elucidation. And the group known as the *Udghāṭitajña* was of an intellect of which as if the door had already been open, and they needed no more than a mere guidance and hint; they could think for themselves; they made their own researches and made original contributions. There were thus required both tutorial coaching and mass or congregational lectures.[1] The aim of the education is stated to have been to unfold the capacities of the student through proper means in order to make his life full of meaning for him as well as for the society. And in order to bring out the latent abilities of

[1] The inference of Mr. Sankalia that at Nalanda University the method of teaching was entirely tutorial does not appear to be accurate. His source of information is the advanced students like Hiuen Tsiang; they would not be required to join big classes for which there were specified halls. Our research student never works in a class; he discusses his difficulties individually with his teacher or teachers.

a student it was necessary to endeavour a harmonious development of his knowledge, work and character. It was, therefore, required to have assistance from two classes of teachers. The Āchārya was responsible for the teaching of all *Vidyās* and the Upādhyāya for building up character. The ordinary teacher is stated to possess at least twenty-five kinds of qualifications. He was required to look after the student all times and carefully in order to ascertain the good and bad habits of the student, his addiction and weaknesses, to provide for his rest and recreation, to know of his happiness and sorrow, to see if he has enough to eat and if his taste is satisfied, to distribute the good stuff properly, to encourage the student, to hold out hopes that his ambition would be fulfilled, to observe the working of his mind and his external movements, to warn him not to keep bad company, to mend his errors and not to turn him out when he is in trouble, to keep a friendly heart for him, and to cherish a genuine fatherly ambition with a view to making an expert of him in all possible *Vidyās* and an accomplished man through education. Different Āchāryas were placed in charge of different *Vidyās* or departments of education.

Sanskrit being the medium of education, *Śabdavidyā*, literally phonology, implying mainly grammar, had to be taken at the primary stage. Mr. Sankalia on the authority of Newman has correctly elucidated the vital importance of impressing at the outset upon the boy's mind "the idea of science, method, order, principle and system of rule" through the study of grammar.[1] This incidentally supplied the necessary knowledge of language and literature. It was followed by *Hetuvidyā* or logic which developed the reasoning faculty of students, and *Śilpavidyā* or science of fine arts, which inclucated in students an aesthetic sense

[1] *Sankalia*, p. 142.

consisting of symmetry, proportion and beauty. After this general education special and technical studies like *Chikitsāvidyā* or medicine and surgery could be undertaken by qualified students. Although theology was a compulsory subject even at the University stage, the *Adhyātmavidyā* or the science of universal soul for the attainment of the supreme knowledge could be taken up only by a few specially endowed with necessary inclination and acquired qualifications.

It has been convincingly shewn from the historical evidences that there was no difficulty for employment of University graduates by the state and the society. The number of qualified graduates, however, appears to have been limited, eight out of ten candidates having ordinarily failed at the highest examinations held at Nalanda University.

Except for the foreigners of the status of Hiuen Tsiang, the entrance examination of Nalanda University appears to have been very stiff. Those seeking admission after the completion of their studies at Universities like that at Valabhi had to pass through what is figuratively called six gate-keepers; these posts are expressly stated to have been held by very learned professors. It is, however, not clear if this entrance-examination was of six kinds for so many classes of students or each student had to pass six examinations one after another. For those who held the diploma of *Paṇḍita* recognised by the King there appear to have been four kinds of examination known as *Parīkshā*, *Upaparīkshā*, *Tulanā* and *Gaveshaṇā*. *Parīkshā* was the ordinary examination both written and *viva voce*. *Upaparīkshā* appears to have been a further test or chance on the basis of a student's day-to-day work, especially for those who were *Padaparama* and could not pass the public examination and yet had to be given a sort of certificate for their general proficiency. The test on *Tulanā* or

comparison was a sort of debate in which the depth of knowledge, quick reply and ready expression were compared among the intending debators. It was something like the original tripos examination in which two debators sitting upon three-footed stools had to debate certain questions and on their comparative merit the examiners who were with the candidates throughout passed a judgment. This type of examination at Nalanda University appears to have been particularly noticed by Hiuen Tsiang, I-Tsing and others. The *Gaveshaṇā* or research was a test disclosed by the learned books on various subjects written by the advanced students and Professors at first grade Universities like that at Nalanda.

Incidentally it is of interest to recall that the oldest known periodic test was that held in China in B. C. 2200 and that held in B. C. 1115 after a thousand years was for the purpose of selection of officers for the public service. "The system of University examination of the middle ages in Europe was also derived from the methods followed in recruiting apprentices by th trade guilds." The first examinations were on civil and common law held at Bologna after 1219 A. D. and at the end of the thirteenth century at Paris.

The University examination consisted of two parts. The first part was conducted in private and included an inquiry into the candidate's residence, attendance at lectures, performance of exercises and contents of the prescribed books. The second part was a purely formal public discussion on the thesis presented by the candidate.

The object of the Examination was—

> "To increase a student's alertness, his power of comprehending new ideas, and his ability quickly and surely to assimilate them to his own, and his capacity to grasp a (new) subject rather than to exhibit his mute and solitary

reviewing and cramming of the prescribed books."

The object of these examinations identical to those held at Indian Universities was to test—

(*i*) the knowledge or, more exactly, the power of restating facts and arguments of a kind that may be learnt by rote, and

(*ii*) the power of doing or writing something like a letter etc.

"The teaching and Examination functions of a University were dissociated in London in 1836 and until 1858 the London Examinations were open to students of affiliated colleges, and the teachers had no share in the appointment of examiners or in determining the curricula for the examinations." "The standard of difficulty set by the University of London was a very high one, very much higher than the corresponding standards at Oxford and Cambridge. In 1900 University of London was constituted as a teaching University with provisions for the system of examinations by External examiners for external students together with Internal examiners for internal students in which the teachers and external examiners are associated."

Two kinds of questions set in written examinations were :

(1) A number of questions requiring short answers and intended to test the range of the candidate's knowledge.

(2) A few questions requiring long answers showing constructive skill and mastery of the subject and intended to test the candidate's powers of coordination and reflection.

Thus it will be noticed that so far as University examinations at ancient Indian Universities are concerned nothing new has been discovered by the long experience of the western world. And the so-called introduction of University education in India from the west is a mere irony of fate, because following the disappearance of Hindu India the first thing what the early Muslim invaders did was to destroy all the University buildings and annihilate all the "shaven headed" teachers to such an extent that there survived none to decipher the titles of the precious books left after the deliberate burning of the famous libraries of which the Chinese and Tibetan travellers supply vivid descriptions.[1]

[1] This article was originally published in the *Twentieth Century*, July, 1935, and under a different title and in a different form in *Science and Culture*, December, 1935; extracts from it were also quoted in the *Modern Review*, August, 1935, pp. 209-210.

A SHORT NOTE ON THE KANDAHĀ INSCRIPTION OF KING NARASIṀHADEVA OF MITHILĀ

BY

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While giving the description of the Kandahā inscription in the March 1934 issue of the *Bihar and Orissa Research Society Journal*, Mr. K. P. Jayaswal remarks "the letters show that the present Maithilī script has not changed much in the last five centuries. One of the very few features of the change is the position of the dot to the *rakāra*.[1] It is placed, in the inscription, in the middle of the triangle, while it is given below the letter at present."

To this remark of Mr. Jayaswal, I wish to point out that it is entirely groundless as it is not corroborated by the actual facts. The Maithilī script, as is quite evident from the very inscription whose facsimile is given in that very issue of the Journal, appears to have undergone several changes in the course of these centuries. The following table will make this point quite clear :

Letters	As found in the Kandahā inscription itself	Present forms	Remarks
Ta ...	ਤ (Line 1)	ত	The slanting upper stroke no longer exists. The letter is, at present, entirely separated from the top-line.

[1] The expression *rakāra* is wrong. It ought to be expressed as *repha*, which is the classical pronunciation of the term.

Letters	As found in the Kandahā inscription itself	Present forms	Remarks
La	ल (Line 1)	ल	The curve portion is written, at present, with a single stroke of pen like a semi-circle, while the form given in the inscription requires double stroke which is still present in the present Bengālī script.
Kṛ ...	कृ (Line 1)	कृ	Full *ka* is no longer written when the vowel ṛ is added to it. This is not a new form even. The present use of the letter is found even in the inscription of Meruvarman of Chambā (8th century A. D.) and of the Paramāra king Udayāditya of Udayapura (11th century).
Tya ...	त्य (Line 1)	त्य	Full *ya* is not written these days.
Ṭa ...	ट (Line 6)	ट	The present form is also very old and can be traced back to the Gift-deed-plates (*Dānapatra*) of king Harṣa of 628 A. D. and also to that of the king Vallabhendra, found in Assam, of 1185.
T (ardhatakāra)	त् (Line 5)	त्	The present form is also as old as the inscriptions of Mahānāman of Buddhagayā of 588 A. D., king Śivagaṇa of Koṭā, of 738, of Rāṣṭrakūṭa of 807, and lastly, of the pillar of Badālaka of 10th century.
Ra ...	र (Line 4)	र	The dot found in the middle of the letter *ra* is now changed into a dash joining the two sides. It is never put below the letter as Mr. Jayaswal thinks. He is, perhaps, led

Letters	As found in the Kandahā inscription itself	Present forms	Remarks
			to think so under the influence of the present Bengālī script which alone puts a dot below the letter ***ra***. A dot is, however, put below the letter *va* sometimes in the present Maithilī script. Again, putting a dash in the middle of *ra* is not a new development as it is found in the pillar inscription of Badālaka of the time of Nārāyaṇapāla of the 10th century and also in the inscription of Udayāditya of Udayapur of the 11th century.

Besides, there are several other changes found in the Maithilī script during these centuries. The peculiar manner of adding vowels to the consonants is a unique feature of the Maithilī script which is perhaps not found in any northern Indian script.

THE COMPUTATION OF THE BHAGAVADGITA

BY

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Traditional Clue

षट् शतानि सविंशानि श्लोकानां प्राह केशवः ।
अर्जुनः सप्तपञ्चाशत् सप्तषष्टिं तु सञ्जयः ॥४॥
धृतराष्ट्रः श्लोकमेकं गीताया मानमुच्यते ॥

—*Mahābhārata, Bhīṣma-parvan, Adhyāya 43*

"Keśava (Śrī-Bhagavān or Kṛṣṇa) has spoken 620 *ślokas*, Arjuna 57, Sañjaya 67, and Dhṛtarāṣṭra 1 *śloka*. (This) is said (to be) the computation of the Gītā."

These words are found in the Mahābhārata as is borne out by Nīlakaṇṭha, the commentator, in his *Bhārata-bhāva-dīpa;* and some editions of the great epic contain them in the beginning of *Adhyāya* 43 of the *Bhīṣma-parvan*, the preceding *adhyāya* (*i.e.*, 42nd) being the 18th *adhyāya* of the Bhagavadgītā.

There is a difference of opinion on the point whether these lines form part of the genuine Mahābhārata. The famous commentator Nīlakaṇṭha remarks (— "गीता सुगीता कर्तव्या इत्यादयः सार्धाः पञ्च श्लोका गौडैर्न पठ्यन्ते।") that the

Northerners* do not recognise the (first) 5½ verses† (of *Adhyāya* 43) beginning with the words '*Gītā sugītā kartavyā.*'

If we believe Nīlakaṇṭha (and there is no reason why we should not), the 43rd *adhyāya* of the *Bhīṣma-parvan* according to the *Northern*‡ *recension* of the Mahābhārata goes without the lines in question, and, the *Southern recension*, where they existed in the times of केशव काश्मीरि भट्ट, वरवरमुनि and श्रीधरस्वामी (*i.e.*, in the 14th, 12th and 11th centuries A.C.), could be expected to provide a room for them.

The Bombay and Kumbakonam editions of the Mahābhārata contain the lines (i.e., 5½ stanzas) quoted in our footnote; but as to the preservation of the Mahābhārata text in any typical recension they are far from being satis-

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* Pandits of the South Indian communities have been calling Northerners as गौडः (*cf.* the division of Indian Brahmans into 5 गौड and 5 द्राविड sections; the terms गौड and द्राविड in नैष्कर्म्यसिद्धि ४।४४).

† गीता सुगीता कर्तव्या किमन्यैः शास्त्रसङ्ग्रहैः ।
या स्वयं पद्मनाभस्य मुखपद्माद् विनिःसृता ॥१॥
सर्वशास्त्रमयी गीता सर्वदेवमयो हरिः ।
सर्वतीर्थमयी गङ्गा सर्ववेदमयो मनुः ॥२॥
गीता गङ्गा च गायत्री गोविन्देति हृदि स्थिते ।
चतुर्गकारसंयुक्ते पुनर्जन्म न विद्यते ॥३॥
षट्शतानि सविंशानि श्लोकानां प्राह केशवः ।
अर्जुनः सप्तपञ्चाशत् सप्तषष्टिं तु सञ्जयः ॥४॥
धृतराष्ट्रः श्लोकमेकं गीताया मानमुच्यते ॥
भारतामृतसर्वस्वगीताया मथितस्य च ॥५॥
सारमुद्धृत्य कृष्णेन अर्जुनस्य मुखे हुतम् ॥५½॥

—(महाभारते भीष्मपर्वणि ४३तमेऽध्याये)

‡ Dr. Sukthankar in his B.O.R. Institute (Poona) edition of the *Ādiparvan* (Prolegomena, p. LXVII) takes the word गौड used by Nīlkaṇṭha, a Mahārāṣṭra Brahman, to refer to the Bengali recension. If this be the correct interpretation, these verses formed part of all Indian MSS. of the Mahābhārata except those representing the Bengali recension.

factory. The Bhandarkar Research Institute, Poona, has commenced the publication of a critical edition of the Mahābhārata. But it will take time to lay its hand on the *Bhīṣma-parvan* for its publication, and till then we shall remain in the dark as to what its editor may be thinking of, or may, in the long run, decide about, the history of the above-mentioned lines containing a clue to the method of counting the number of verses severally assigned to the individual speakers of the Bhagavadgītā. Prof. P. P. S. Śāstrī of Madras has brought out an edition of the Mahābhārata, which, in his own words, being the result of his "endeavour to restore the text of the Southern Recension as approximately as may be possible to what it must have been about 1000 A.D." is "as critical as possible in a handy and popular form." However, to our astonishment, it omits not only the 5½ verses in question but even the entire *adhyāya* containing them. Its *Adhyāya* 40 is *Adhyāya* 18 of the Bhagavadgītā and *Adhyāya* 41 is *Adhyāya* 44 of the Bombay and Kumbakonam editions. We are thus handicapped as to the true history of the 5½ verses that have traditionally preserved to us the valuable information on the important subject of our present enquiry.

However, be the decision on the question of the inclusion of the above-mentioned 5½ stanzas in the original Mahābhārata what it may, one fact is quite evident that they bear testimony to an early attempt of the custodians of the Mahābhārata in the direction of fixing the size and shape of the pure Bhagavadgītā (Divine Song) so as to have left no room for any interpolation therein.

Apparent Discrepancy

Now, the whole of the Gītā is expected to contain $(620 + 57 + 67 + 1 =)$ 745 *ślokas*, according to the traditional figures recorded in the lines noted above. But, as is generally understood, the number of all the verses of the extant

'song Divine' does not exceed 700, as would appear from the following table :—

Adhyāya	Dhṛtarāṣṭra	Sañjaya	Arjuna	Śrī-Bhagavān	Total.
I	1	$19\frac{1}{2}$ (i.e., 2-$20\frac{1}{2}$) $4\frac{1}{2}$ („ 24-$27\frac{1}{2}$) 1 („ 47)	$2\frac{1}{2}$ (i.e., $20\frac{1}{2}$-23) $18\frac{1}{2}$ („ $27\frac{1}{2}$-46)	...	47
II	...	1 (i.e., No. 1) 2 („ 9-10)	5 (i.e., 4-8) 1 („ 54)	2 (i.e., 2-3) 43 („ 11-53) 18 („ 55-72)	72
III	...	...	2 (i.e., 1-2) 1 („ No. 36)	33 (i.e., 3-35) 7 („ 37-43)	43
IV	...	...	1 (i.e., No. 4)	3 (i.e., 1-3) 38 („ 5-42)	42
V	...	...	1 (i.e., No. 1)	28 (i.e, 2-9)	29
VI	...	...	2 (i.e., 33-34) 3 („ 37-39)	32 (i.e. 1-32) 2 („ 35-36) 8 („ 40-47)	47
VII	...	...	...	30 (i.e., 1-30)	30
VIII	...	...	2 (i.e., 1-2)	26 (i.e., 3-28)	28
IX	...	...	...	34 (i.e. 1-34)	34
X	...	...	7 (i.e., 12-18)	11 (i.e. 1-11) 24 („ 19-42)	42
XI	...	6 (i.e., 9-14) 1 („ No. 35) 1 („ „ 50)	4 (i.e., 1-4) 17 („ 15-31) 11 („ 36-46) 1 („ No. 51)	4 (i.e., 5-8) 3 („ 32-34) 3 („ 47-49) 4 („ 52-55)	55
XII	...	...	1 (i.e., No. 1)	19 (i.e, 2-20)	20
XIII*	..	...	*	34 (i.e., 1-34)	34
XIV	...	...	1 (i.e., No. 21)	20 (i.e., 1-20) 6 („ 22-27)	27
XV	...	...	...	20 (i.e., 1-20)	20
XVI	...	...	...	24 (i.e., 1-24)	24
XVII	...	...	1 (i.e., No. 1)	27 (i.e., 2-28)	28
XVIII	...	5 (i.e., 74-78)	1 (i.e., No. 1) 1 („ „ 73)	71 (i.e., 2-72)	78
Total	1	41	84	574	700*

* Śrī Śaṅkarācārya and other *Bhāṣyakāras* are not aware of the existence of the verse "प्रकृतिं पुरुषं चैव क्षेत्रं क्षेत्रज्ञमेव च । एतद्वेदितुमिच्छामि

Comparing this result with the figures known from the *Bhīṣma-parvan*, as follows,

	Dhṛtarāṣṭra	Sañjaya	Arjuna	Śrī-Bhagavān	Total
Result of the table	1	41	84	574	700
Old tradition ..	1	67	57	620	745

we at once notice that, except for the only figure (of one verse) for Dhṛtarāṣṭra, which is the same, in both places, there is a *two-fold discrepancy* discernible between the figures for other speakers. For, while we notice a decreasing proportion in the number of verses of Sañjaya, Śrī-Bhagavān and the total, the number of Arjuna's verses largely increases, in the result of our tabular calculation in comparison with the figures recorded in *Adhyāya* 43 of the *Bhīṣma-parvan*. The question is

'*How to account for this two-fold discrepancy?*'

Should we discard the ancient tradition as worthless in view of the actual figures obtained from our own calculation pointing out decrease on one side and increase on the other? Or, can we get at the method employed or principles involved in the ancient computation and remove the present difference? The writer of these lines emphatically opines that until a thorough examination and patient study pursued on strictly scientific lines have proved its futility or hollowness, no ancient heritage has to be finally rejected. And in the present case the word *śloka* used in the lines in

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ज्ञानं ज्ञेयं च केशव ॥" which is put in the mouth of Arjuna at the very outset of *Adhyāya* XIII in some popular editions of the Gītā. It is also noteworthy that the total number of the Gītā verses is said, by Śrī Śaṅkarācārya and others, to be exactly 700.

question supplies us with the clue to the traditional or ancient method of the computation of the Bhagavadgītā.

TWO PRINCIPLES OF THE ANCIENT COMPUTATION

The most fundamental principle generally followed in measuring the length of a Sanskrit work in prose or verse or both is that of counting together all its syllables and, after dividing them by 32 (the number of syllables or *akṣaras* contained in an *Anuṣṭubh* verse technically known as a *śloka*), of taking the quotient to represent the number of *ślokas* popularly called the *Grantha-saṅkhyā* of that particular work. This is how the Mahābhārata (containing also prose portions), just like the whole Vedic literature under its three branches (Kāṇḍas) of *Karma*, *Upāsanā* and *Jñāna* (including a larger number of works in prose than poetry), is to be measured in 100,000 *ślokas*. The Gītā is composed of verses in either *Anuṣṭubh* or *Triṣṭubh* metre, the former unit including 32 and the latter generally 44 syllables or *akṣaras*, and by the application of the present principle, the keynote of the traditional method of computing the ancient works, if, while counting together all the verses in the Gītā, we evaluate the *Triṣṭubh* verses by the measure of the *Anuṣṭubh* metre, we may expect ourselves to arrive at a figure different from 700, that may take us nearer to the traditional figure of 745. The number of the *ślokas* of the whole work as well as of those assigned to different speakers is thus sure to increase in proportion to the surplus of the *Triṣṭubh* stanzas weighed in *Anuṣṭubhs*. This may remove the discrepancy on the side of decrease in the number of verses we obtained for Sañjaya (*viz.*, 41), Srī-Bhagavān (574) and the total (700), in the result of our tabular calculation as compared to the traditional figures of 67, 620 and 745 respectively.

But how to obviate the difficulty about the number of Arjuna's verses, which instead of thus decreasing has

actually increased from 57 of the traditional record to 84 of our tabular result? An insight into the nature of the *Śrī-Kṛṣṇārjuna-saṁvāda* or the dialogue proper between Śrī-Kṛṣṇa and Arjuna yields another principle to determine the exact verses to be assigned to Arjuna, the valuation whereof may remove the discrepancy on this score, too. We see that Arjuna's speeches, which are generally short, are marked by the inquisitiveness of a pupil and amount to a request or a question, on his part, to which Śrī-Bhagavān responds in apt terms typical of a teacher. The only two *adhyāyas* containing long speeches from Arjuna are I and XI. In *Adhyāya* I, *ślokas* $27\frac{1}{2}$—46, amounting to Arjuna's grief (*śoka*) and delusion (*moha*), the very seed of the message of Śrī-Bhagavān, we see nothing foreign added to Arjuna's native capacity. He speaks in the same strain once again, though briefly, in Adhyāya II, verses 4—8. In *Adhyāya* XI, *ślokas* 1—4, he, showing his satisfaction with the secret knowledge imparted to him by Śrī-Bhagavān, requests the latter to reveal to him His highest form. Śrī-Bhagavān has, however, complied with this request of Arjuna, His greatest devotee and friend, and virtually blesses him with divine vision, since that form of His was beyond the scope of the devotee's human eye. Now, as a result of this divine vision, verses 15—31 and 36—46 essentially of the nature of a *stuti*, do not come under the average part of Arjuna in the dialogue form and should not be credited to him. So, if we exclude these 28 verses, all in *Triṣṭubh* metre, all other verses bearing the stamp of Arjuna's speech in the Gītā may possibly come to the value of 57 *ślokas*.

But, again, to whose speeches are these 28 verses to be added if not to Arjuna's? We know that but for the Divine Eye lent for the time being by the Divine Lord to Arjuna, His ideal worshipper and devotee, the latter would have remained incapable of having a glimpse of the

Viśva-rūpa (Universal Form) and eulogizing the same. Hence, what comes out from his lips, in that mood of Divine vision, is really due to Śrī-Bhagavān, to whom it would be, therefore, reasonable to associate it. So, verses 15—31, and 36—46 of *Adhyāya* XI should form part of the number of *ślokas* assigned to Śrī-Bhagavān.

With the application of these two principles let us now work out a fresh computation as is shown by the following table :—

Adhyāya.	Dhṛtarāṣṭra		Sañjaya		Arjuna		Śrī-Bhagavān		Total.
	Verse No.	Syllables.	V. Nos.	S.	V. N.	S.	V. N.	S.	Syllables
I	(1)	32	(2-20½) (24-27½) (47)	624 144 32	(20½-23) (27½-46)	80 592	...	...	1504
II	..	...	(1) (9-10)	32 64	(4) (5) (6) (7-8) (54)	32 *44 *46 *88 32	(2-3) (11-19) (20) (21) (22) (23-28) (29) (30-53) (55-69) (70) 71-72	64 288 *44 32 *44 192 *45 768 480 *44 64	2408
III	...	...	..		(1-2) (36)	64 32	(3-35) (37-43)	1056 224	1376
IV	...	...	...	..	(4)	32	(1-3) (5-42)	96 1216	1344
V	...	...	..		(1)	32	(2-29)	896	928
VI	...	..	...	.	(33-34) (37-39)	64 96	(1-32) (35-36) (40-47)	1024 64 256	1504
VII	...	...	...	.	...	...	(1-30)	960	960
VIII	...	..	...	.	(1-2)	64	(3-8) (9) (10) (11) (12-27) (28)	192 *44 *45 *44 512 *44	945

	Dhṛtarāṣṭra		Sañjaya		Arjuna		Śrī-Bhagavān		Total
Adhyā-ya.	Verse No.	Sylla-bles.	V. Nos.	S.	V. N.	S.	V. N.	S.	Syllables
IX	...	...	.	...	...	.	(1-19) (20-21) (22-34)	608 *88 416	1112
X	...	...	...	..	(12-18)	224	(1-11) (19-42)	352 768	1344
XI	..	...	(9-14) (35) (50)	192 *44 *44	(1-4) (51)	129 32	(5-8) *(15-31)* (32-34) *(36-46)* (47-49) (52-55)	128 *748 *132 *484 *132 128	2192
XII	...	...	...	.	(1)	32	(2-20)	608	640
XIII	...	...	...	...	...	...	(1-34)	1088	1088
XIV	...	...	...	..	(21)	32	(1-20) (22-27)	640 192	864
XV	...	...	...	..	...	.	(1) (2) (3) (4-5) (6-14) (15) (16-20)	32 *44 *45 *88 288 *44 160	701
XVI	...	...	...	...	...	...	(1-24)	768	768
XVII	...	...	...	.	(1)	32	(2-28)	864	896
XVIII	...	...	(74-78)	160	(1) (73)	32 32	(2-72)	2272	2496
Total No. of sylla-bles.	...	32	...	1336	...	1843	..	19855	23066
Valua-tion in *ślokas* (of 32 sylla-bles each.)	...	1 *śloka*	...	41 *ślokas* 24 syllables.	...	57 *ślokas* 19 syllables.	..	620 *ślokas.* 15 syllables.	720 *ślokas* 26 syll.

* In the above table, the asterisks indicate the *Triṣṭubh* metre and the italicized figures of *Adhyāya* XI stand for Arjuna's speeches counted as Śrī-Bhagavat's.

Thus we get one *śloka* for Dhṛtarāṣṭra, 57 *ślokas* and 19 *akṣaras* for Arjuna, and 620 *ślokas* and 15 *akṣaras* for Śrī-Bhagavān, not differing much from the figures of 1 (one), 57 and 620 *ślokas* assigned respectively to the very same speakers by the Mahābhārata tradition. Evidently, the ancients, in their computation of the Gītā did not take the fraction of a *śloka* into consideration; and so we have to take only full *ślokas* of the total number for Arjuna and Srī-Bhagavān [as well as of the grand total] into our account and leave out the excess of *akṣaras* (syllables) in these cases. If we were to believe that Arjuna has uttered one *śloka* in the beginning of *Adhyāya* XIII and the latter contains 35 instead of 34 *ślokas*, the whole number of *ślokas* for Arjuna would exceed the limit, which is not desirable. Hence *Adhyāya* XIII contains only 34 *ślokas*, all for Śrī-Bhagavān, and no *śloka* for Arjuna.

We are still confronted by a problem awaiting its solution, *viz.*, that the number for Sañjaya and consequently the grand total falls short by about 25 *ślokas*, in spite of our discovery and application of special principles. How to get out of this difficulty? We have to meet this question with something which must form part of the Gītā text itself.

A Third Principle.

So far, we have counted every syllable (*akṣara*) of all the verses of the Bhagavadgītā; but we have not touched the colophons in prose marking the termination of the individual *adhyāyas* or subdivisions of that book. The colophons in a Sanskrit work are always considered to be its genuinely component parts unless a proof to the contrary shows them to be otherwise. In the light of this principle the prose colophons are to be treated as a legitimate part of the Gītā like verses themselves.

But to whom are the colophons of the Divine Discourse to be assigned? There are only 4 persons to whom the whole Gītā is due. Its main subject forms a dialogue between Keśava and Arjuna;* and the colophons are quite apart therefrom. Dhṛtarāṣṭra plays no other part than that of putting a question, at the very outset, to Sañjaya, who, in reply to it, reproduces the whole dialogue as it took place between Arjuna and Bhagavān Śrī-Kṛṣṇa with his own remarks wherever there is an occasion or a necessity for them to be introduced. Thus, the whole of the Gītā, in the shape it has come down to us, is to be understood to have been told by one person, *i.e.*, Sañjaya (to Dhṛtarāṣṭra). The colophons should, therefore, form an indispensable part of Sañjaya's speech. The computation of these colophons is as follows:—

The words **"इति श्रीमद्भगवद्गीतासूपनिषत्सु ब्रह्मविद्यायां योगशास्त्रे श्रीकृष्णार्जुनसंवादे"** amounting to 31 syllables are common to all the 18 colophons marking the terminations of the 18 *adhyāyas;* and so, for these words of 31 syllables repeated 18 times, we get $31 \times 18 = 558$ syllables. The remaining portions of the colophons recording the names of the individual *adhyāyas* are read differently in all the 18 places. But, again, there is a difficulty in the way of our counting their syllables inasmuch as, in a number of cases, the colophon for or the name of one and the same *adhyāya* offers different readings in different books of the Śrīmad-Bhagavadgītā. The readings found in the Mahābhārata itself, of which the *Bhagavadgītā-parvan* (*Adhyāyas* 13—42) forms a sub-*parvan* of the *Bhīṣma-parvan*, may, however, be taken as the standard ones. The latest edition of the Mahābhārata (Southern Recension) by Prof. P. P. S. Śāstrī of the Presidency College, Madras, does not contain the names of the *adhyāyas* of the Bhagavadgītā in the

* *Adhyāya* XVIII, *ślokas* 74 and 76.

colophons. The two Calcutta editions are not easily available. But it is a matter of great satisfaction that the other two, *i.e.*, Gaṇpat Kṛṣṇaji (Bombay) and Madhva Vilās Book Depot (Kumbakonam), editions (except in one case of the colophon to *Adhyāya* XI) give identical readings, the computation whereof would be as follows :—

Adhyāya No.	The latter parts of colophons	Valuation in syllables
I	—ऽर्जुनविषादयेागो नाम प्रथमेाऽध्याय:	14
II	साङ्ख्ययेागो नाम द्वितीयेाऽध्याय:	11
III	कर्मयेागो नाम तृतीयेाऽध्याय:	11
IV	यज्ञविभागयेागो नाम चतुर्थोध्याय:	14
V	* सैन्यासयेागो नाम पञ्चमेाऽध्याय:	12
VI	अध्यात्मयेागो नाम षष्ठोऽध्याय:	11
VII	ज्ञानयेागो नाम सप्तमेाऽध्याय:	11
VIII	† तारकब्रह्मयेागो नामाष्टमेाऽध्याय:	13
IX	राजविद्याराजगुह्ययेागो नाम नवमेाऽध्याय:	17
X	विभूतियेागो नाम दशमेाऽध्याय:	12
XI	‡ विश्वरूपदर्शनयेागो नामैकादशोऽध्याय:	16
XII	भक्तियेागो नाम द्वादशोऽध्याय:	11
XIII	क्षेत्रक्षेत्रज्ञविभागयेागो नाम त्रयेादशोऽध्याय:	18
XIV	गुणत्रयविभागयेागो नाम चतुर्दशोऽध्याय:	17
XV	पुरुषोत्तमयेागो नाम पञ्चदशोऽध्याय:	15
XVI	देवासुरसम्पद्विभागयेागो नाम षोडशोध्याय:	18
XVII	श्रद्धात्रयविभागयेागो नाम सप्तदशोऽध्याय:	17
XVIII	संन्यासयेागो नामाष्टादशोऽध्याय:	12
	Total number of syllables for these parts	250

* Most of the Gītā books read 'कर्मसंन्यास-येागो,' which should be accepted as the correct name for *Adhyāya* V.

† Although the names 'ब्रह्माक्षरनिर्देशो' and 'महापुरुषयेागो' found in some Gītā books would also give the same number of syllables as 'तारकब्रह्मयेागो', yet we have followed the Mahābhārata in the nomenclature of the Gītā colophons.

‡ The present reading is found in the Kumbakonam edition. The Bombay and Calcutta editions read only 'विश्वरूपदर्शनं नाम', omitting the word 'येागो' before 'नाम'. If the latter reading be adopted,

It is strange that both the Bombay and Kumbakonam editions give one and the same name for the 5th as well as the 18th *adhyāya*. *Saṁnyāsa-yoga* should, however, be accepted as the name for the 18th *adhyāya* only, while *Karma-saṁnyāsa-yoga*, as met with in majority of Gītā books, should be the name of the 5th *adhyāya*. This change would give us 2 syllables more against the 5th *adhyāya*. But the total of 250 may remain unchanged for the fact that the Bombay and Calcutta editions read only 'विश्वरूपदर्शनं' in place of 'विश्वरूपदर्शनयोगो' of the Kumbakonam edition and the former reading would give us 2 syllables less against the 11th *adhyāya*.

Thus, all the 18 colophons in their entirety add (558 + 250, or) 808 syllables, or $808/32 = 25\frac{8}{32}$ *ślokas*, more to the number of *ślokas* proper ($41\frac{24}{32}$) for Sañjaya. By the addition of both these figures ($41\frac{24}{32} + 25\frac{8}{32}$) we obtain exactly 67, which is the number of *ślokas* said to have belonged to Sañjaya according to the information available in the Mahābhārata itself.

Result

Thus, the respective figures of 1, 67, $57\frac{19}{32}$ and $620\frac{15}{32}$ for Dhṛtarāṣṭra, Sañjaya, Arjuna and Keśava, arrived at in the light of the special principles elucidated above, tally [almost] exactly with the numbers (1, 67, 57 and 620) of *ślokas* credited to these four characters of the Bhagavadgītā in *Adhyāya* 43 of the *Bhīṣma-parvan*. The *grantha-saṅkhyā* of the Gītā, thus obtained, would come to $746\frac{2}{32}$ (our previous total of $720\frac{26}{32}$ + colophons of $25\frac{8}{32}$) *ślokas*. But as, according to our previous decision, the excess of

it would give us only 14 syllables against the eleventh *adhyāya*. This loss of 2 syllables can well be compensated by the addition of the word 'कर्म' (yielding the same number) before the name for the fifth *adhyāya*.

syllables in the separate figures for the speakers has to be left out, the *grantha-saṅkhyā* of the whole Gītā should be taken to remain $[1+67+57+620=]$ 745 *ślokas* and not exceed this number by $19+15$ or $26+8$ syllables ($=1\frac{2}{32}$ *śloka*). This is also because, in view of the fact that in the Gītā we have the *Triṣṭubh* metre thrice (II. 29; VIII. 10; and XV. 3) of 45 and once (II. 6) even of 46 against 44 syllables, its normal size, and similarly the *Anuṣṭubh* metre once (XI. 1) of 33 instead of 32 syllables, the deduction of these six irregular syllables would give us, over and above 745 *ślokas*, only 28 syllables, which do not amount to a *śloka* and are, therefore, to be left out.

Importance of the Present Study

The above investigation is not to be considered as useless like the examination of a crow's teeth (**काकदन्तपरीक्षावत्**). It is important for the following points :—

(1) The ancient tradition of the computation of the whole of the Gītā as recorded in the Mahābhārata (*Bhīṣma-parvan*, *Adhyāya* 43), has preserved the textual purity of the Bhagavadgītā against all interpolations.

(2) The 13th *adhyāya*, contains only 34 *ślokas*, all from Śrī-Bhagavān (Keśava or Srī-Kṛṣṇa); and the verse,

"प्रकृतिं पुरुषं चैव क्षेत्रं क्षेत्रज्ञमेव च ।
एतद् वेदितुमिच्छामि ज्ञानं ज्ञेयं च केशव ॥,"

credited to Arjuna in popular editions, forms no part of the original Bhagavadgītā and did not exist in the times of its earlier commentators, and, consequently, they could not be expected to write anything regarding it.

(3) The colophons at the end of the *adhyāyas* form an integral part of the original Bhagavadgītā and must, as such, be included in its *pāṭha*. Their text also can well

nigh be fixed in the light of the fact that their traditional reading has to afford 808 syllables in all.

(4) As according to the Mahābhārata record the computation of the Gītā including, as shown above, both the verses and the prose colophons ought not to exceed 745 *ślokas* in all, the small sentences like धृतराष्ट्र उवाच, सञ्जय उवाच, अर्जुन उवाच, श्रीभगवानुवाच, repeatedly met with in the work and used for introducing verses of those various speakers are decidedly no indispensable part of Sañjaya's narration of the dialogue between Śrī Kṛṣṇa and Arjuna before Dhṛtarāṣṭra in reply to the latter's question and could not possibly fall under the four headings of the settled computation of the Gītā; and any one who excludes them in course of his *Pāṭha* (पाठ, daily recitation) does nothing seriously wrong. These introductory sentences, too, may be treated as regular part of the Gītā; but, in that case, they are to be assigned to the author of the Mahābhārata and certainly not to the four speakers named above. The present writer has also worked the *adhyāya*-wise computation of all such sentences, which, put together, comes to more than 10 *ślokas* and their addition to any one or all the four headings of the computation of the Gītā would not only go without justification but also mean a serious blow to the figures of the established computation of the work in question.

(5) Whenever we are to calculate the *granth-saṅkhyā* or *ślokas* of a work, the word *śloka* is generally to be taken as an equivalent of an *Anuṣṭubh* verse or 32 syllables. This explains the fact that, even according to [the *Anukramaṇikādhyāya* of] the Mahābhārata itself, the actual number of its verses comes to a little more than 84,000 and was almost the same in Nīlakaṇṭha's time (17th century), as is clear from its Bombay and Calcutta editions. And, consequently, modern editors or critics of the Mahābhārata

are mistaken in their attempt or anxiety to count in it 100,000 'verses' instead of '*ślokas*' of the traditional sense of *grantha-saṅkhyā* ("लक्षं तु वेदाश्चत्वारो लक्षं भारतमेव च")

(6) The speech of Arjuna in the form of a *stuti* due to the Divine Vision granted him by Śrī-Bhagavān is to be treated as part of the Divine Lord's speech.

(7) The original Bhagavadgītā never existed in (any form) less than the present 700 verses and it was in this very shape and size that this monumental discourse was included in the *Bhīṣma-parvan* of the Mahābhārata. This last point has been a subject of great controversy and involves a discussion as to whether the original Mahābhārata was a work in a hundred thousand (100,000) *ślokas*. To Prof. P. P. S. Śāstrī is due the credit of settling this point in his introduction to Parts I and II of the *Ādi-parvan*, and accordingly, when the original Mahābhārata itself, amounting to 100,000 *ślokas*, is proved to contain the present Gītā of 18 *adhyāyas*, the controversy regarding the latter's size should also be set at rest.

SECTION III

PHILOSOPHY

ANTI-ARISTOTELIAN THINKERS OF ISLAM

BY

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Introduction.

1. Origin and scope of Islamic Philosophy.

Muslims, to begin with, were a practical type of men, too busy in their affairs, to have time enough to theorise. After a short period, however, when they had settled themselves satisfactorily and the days of the Prophet and the four Caliphs had passed, they found time for, and even the necessity of, speculating over certain problems connected with the attributes of God and the Freedom of Will.

These were the days of the Umayyad princes with Damascus as the capital of Islamic State. Time was now ripe for the Mulims to enter the intellectual field, and the fire now ablaze, was added fuel to by the religious controversies brought forth by the Syrian Christians who possessed certain mutilated and even spurious translations of Greek Philosophers. These Christians had developed a taste for speculation, in so far at least as it helped them in their religious controversies. To be brief, however, "Greek wisdom flowed towards the Muslim East through Harran and Syria. The Syrians took up the latest Greek speculation, *i.e.*, Neo-Platonism and transmitted to the Muslim what they believed to be the real philosophy of Aristotle."[1]

The attitude of the Muslims, now naturally, differed as to the value of this newly-come wisdom. The more orthodox contented themselves with the Revelation and

[1] *Dev. of Met.*, by Iqbal, p. 24.

kept quite aloof from a logic-chopping of religious verities, which act they even condemned as innovation (bida') and hence misleading, quoting a Ḥadīth—perhaps misinterpreting it—that " all innovation is misleading. . . "

A group of Muslims, however, took to it seriously, yet the hold of religion was so strong that men of this group too, could not for once doubt the validity of revelation. Qur'ān was right, but Aristotle too was right. The seeming antinomy, they held, between revelation and reason was based upon a superficial grasp of revealed truth. What they attempted at, was to solve the apparent antinomy in certain points between philosophical and scientific truths on the one hand and religious verities on the other.

A group of thinkers seceded from the orthodox and was called ' Mu'tazalite ' (the dissenters). The difference of attitude towards Hellenism, thus brought forth schisms and groups in Islam, and to take into account the philosophical schismatics only, we find that the first group of thinkers in Islam that seceded itself from the orthodox was named ' Mu'tazalite.' Here it may be made clear that even if there had been no Hellenistic influence over the Muslims, the problem itself which they had had to confront with, namely, that of Free Will and Determinism—for the present leaving out of consideration the problem of the attributes of God—would have created among them a difference of opinion and given them an impetus to philosophize, as it does everywhere else. Yet environments do a great deal affect the trend of thought and they did the same here.

It is controversial whether the first impetus to philosophize among the Muslims was given by the problem of Free will and Determinism or by that of the Logos, or word of God or the Creation of Qur'ān giving rise to theories about the attributes of God. But as Professor Macdonald holds, it is most probable that philosophical speculation did begin

in Islam, as it does everywhere else, in the much perplexing problem of Determinism and Libertarianism. And there are evidences to support this contention, both psychological and historical. Man finds himself placed under environments which mostly he does not himself create, and finds his own actions determined by these environments. He takes his start in life in circumstances other than he would have wished to have and these go a long way in defining his course of action. Moreover, in the physical realm of the Universe he finds a regular chain of causation governing the Universe. This leads him to pass a verdict in favour of Determinism; yet his own inner observations, observations of the self, generate in him a belief to the contrary and upon instinct he feels himself free. This leads him to the other side of the picture and in a state of wonder he fails to harmonise the two views. Historically also we find that the problem of freedom and determinism had been introduced in the days of the prophet himself and certain traditions regarding it are to be found inclined towards. Determinism. This we find to have been the position much before the problem of Logos or the creation of the word or the eternity of it had been brought in the front.

It is safe therefore to hold with Macdonald that speculation in Islam began with the problem of Freedom and Determinism. What shapes it assumed, in different periods, does not concern us presently. O'Leary's treatment of the subject betrays his inclination towards the opposite view, namely, taking the problem of the Logos or the word giving the initiative to philosophise.

We have briefly considered the subject of the origin of Islamic Philosophy and found that it originated in Syria with the problem of Freedom and Determinism and the impetus to it was given by the surrounding people who had a taste for speculation to help them in giving a rationale of their beliefs and dogmas and holding their

own in opposition to other beliefs. It would be too lengthy here to trace the passages in detail through which philosophy came to the Muslims; suffice it here to indicate that it was through their contact with the Christians and Zoroastrians who had their schools at Alexandria, Nisibis, Antioch, Harran, Jundesapur and Edessa that the Muslims were initiated into philosophical problems. We might agree with Professor Nicholson who says that 'Muslim theology, philosophy and science put forth their first luxuriant shoots on a soil which was saturated with Hellenistic culture.'[2]

Scope.

We may now pass on to consider the scope of Islamic Philosophy, which seems to be a very significant problem these days, as a misapprehension of the scope of the subject has been greatly responsible for its negligence. .

There is a world of difference between what we mean by Islamic Philosophy and what we should mean by it. An unfortunate misconception of terminology has largely been responsible for the too often repeated charge against Islamic Philosophy that it lacks in originality; and most of the orientalists are never tired of saying that it never enabled itself to outthink Aristotle or the Neo-Platonists. Yet we shall find, presently on investigation, how baseless and futile such hasty generalizations prove to be. The fact is that, out of numerous schools of thought, there was one that based its thinking directly on a study of Greek thought. This particular group of thinkers was known as 'falāsifah.' "The Arabic writers" says O'Leary, "give the name of failasuf, a transliteration of the Greek φιλόσοφος to those who based their study directly upon the Greek texts either as translators or as students of philosophy, or as the pupils of those who used the Greek Text. The word is used

[2] *Mystics of Islam*, p. 9.

to denote a particular series of Arabic Scholars who arose in the 3rd century A.H. and came to an end in the 7th century, and who had their origin in the more accurate study of Aristotle based on an examination of the Greek Text and the Greek commentators whose work was circulated in Syria and is employed as though these falasifah formed a particular sect or school of thought. Other philosophical students were termed Hakīm or Nāẓir,"[3] and we may add to these 'Mutakallim and Ṣūfī.'

Thus we see that falsifah is not the same as philosophy for us today. Philosophy, the anglicised form of φιλόσοφος is not the same as falsifah the Arabicised form of it. The former is the whole of it while the latter only a part. Philosophy has got a much wider connotation than falsifah. Any speculation that was anti-Greek or even non-Greek *ipso facto* could not be falsifah, while it is a philosophy for us be it Greek or anti-Greek. This is a misconception which has originated either through prejudice or ignorance, and has led a scholar like De Boer to begin Islamic Philosophy with al-Kindī and finish with Averroes, casting only a cursory glance over other—as important if not more—important schools of thought, even leaving some out of consideration.

Thus the scope of Islamic Philosophy has been curtailed down to nearly one-third, if not less, of what it really is through the unfortunate and sad misinterpretation of this one term. It was perhaps due to the over-developed sense of accuracy, exactness and analytic bent of mind of the Muslim scholars that they gave a Greek name to a system of thought that went on Greek lines.

It is difficult to find the logic of selecting a particular school of thought from out of a whole system and trying to find out in it elements which it excludes by its very definition.

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[3] O'Leary, *Arabic Thought and its Place in History*, pp. 135-6.

Falsifah is the name of the Aristotelian system of thought and it is futile to trace in it anti-Aristotelianism. If it goes on anti-Greek lines, it is not falsifah.

Now it is clear that if we find Hellenism and nothing more in the system of the Falsifah, it is what it must in *rerum natura* be. To condemn the whole system as servile imitation on examining a part of it, which itself does not claim any radical deviation from Hellenism, is a meaningless effort.

The space at our disposal does not permit us to show that even this notorious group of Aristotelians is not utterly devoid of originality and a deeper study is bound to disclose that, even among the Mu'tazalites and the Falāsifah, there have been thinkers who did not merely accept Aristotle or the Neo-Platonists as 'Reason personified.'

In the next chapter however, we shall have occasion to see that there are Anti-Aristotelian tendencies even in the systems worked out by the Falāsifah and the Mu'tazalites.

To return now to the main theme of this chapter we may advantageously divide Islamic Philosophy under the following five broad schools of thought:—

1. The Mu'tazalites—Semi-Aristotelians.
2. The Falāsifah—Neo-Platonico-Aristotelians.
3. The Ash'arites—Non-Aristotelians.
4. The Mystico-theological thinkers—Non-Aristotelians.
5. The Mystics proper—Non-Aristotelians.

In the subsequent pages we shall mainly deal with those thinkers only who are not only non-Aristotelian but anti-Aristotelian, casting a cursory glance upon others only in so far as they are helpful in connection with our study of the anti-Aristotelians.

CHAPTER I.

THE PRE-REACTIONARY PERIOD—THE MU'TAZALITES.

"When the Aristotelian Philosophy was made known to the Islamic world it was received almost as a revelation supplementing the Qur'ān. At that time it was very imperfectly understood and the discrepancies between it and orthodox theology were not perceived. Thus the Qur'ān and Aristotle were read together and regarded as supplementing one another in good faith, but inevitably the conclusions, and still more perhaps the methods, of Greek Philosophy began to act as a powerful solvent on the traditional beliefs."[4]

But this sort of unreserved homage to Aristotle did not continue long enough; and thinkers, form amongst the Aristotelian group itself, began to criticize him freely.

Leaving out of consideration the Mu'tazalites before Allaf, we may have a cursory glance over the nature of the Mu'tazalite speculation as such.

The studies of the Mu'tazalites now penetrated deeper than a mere superficial grasp of Aristotelian philosophy; and with a better grasp of Greek thought came a freer criticism of it also. Now they began to look with suspicion upon the sole monopoly they had given to Aristotle and the Neo-Platonists for philosophical speculation. However, this was only an indication of the full-fledged reaction that began some times after; yet it is sure that the seeds of it had been sown by these notorious thinkers.

The most prominent names among the Mu'tazalites are those of Wāṣil bin 'Atā', Mu'badal Juhanī, Abu'l Hudhail al 'Allāf, Ibrāhīm bin Sayyār al Naẓẓām, Bishr bin

[4] O'Leary, *Arabic Thought and its Place in History*, p. 123.

Mu'tamir, Máммar bin 'Abbad al Sullamī, Tumāmeh bin Ashras, Amr bin Bakr al Jāḥiẓ, Jubbāī, Hishām bin al Ḥikam, Abū Hāshim and some others of lesser importance. It would be too lengthy a business, and perhaps beyond the scope of the present work, to form anything like a right estimate of their individual contributions. Suffice it here to point out their attitude and contribution as a group.

Reaction in the history of a people's thought is never a sudden and abrupt output, it is rather gradual and slow, germs of it developing in the beginning in an unnoticed manner and finding time and environment and some potentate intellect as its mouthpiece, it bursts forth with a force which apparently seems to have given birth to it all of a sudden. It is because our main theme is to consider the Anti-Aristotelian group, that though we cannot enter into a detailed discussion of their precursors, we must know what grounds had been prepared and the position reached by the Pre-Ash'arite thinkers. Unless this is taken into consideration we shall not be able to understand fully the significance of the reaction.

Wāṣil bin 'Aṭā', a disciple of Ḥasan al Baṣārī, the famous saint, may be said to be the founder of the Rationalist movement. Till now, orthodox Muslims were inclined towards believing in determinism rather than free will, and in the eternity of the Qur'ān rather than its having been created. The rationalists now took the opposite views and tried to show that Determinism and the co-eternity of the attributes of God with Him were tenable neither on religious nor on philosophical grounds. To believe in determinism, they contended, and along with it in the rewards and punishments in the hereafter was to deprive God of Justice, because only a man who is free to choose between his actions and is not compelled to take a predetermined course can be held responsible for the good or evil that comes of him; otherwise it is tyranny and injustice to

punish a man for a course of action which he could not but take. As for the second problem, namely, the attributes of God, their contention was that if attributes are held to be co-eternal with God, it lands us into polytheism. Even if we take His word to be uncreated it means introducing a duality in His Nature, because either a particular attribute is identical with Him or not. If we take the latter alternative as the Non-Mu'tazalites did, it is in substance positing other Gods besides the One God. The right position, Abu'l Hudhail held, was that 'God is knowing, all powerful, living; and His knowledge, power and life constitute His very essence.'[5] He preached the identity of Essence and Attribute. The Mu'tazalites called themselves, in accordance with their view of the two aforesaid problems, 'Ahlal Tawḥīd Wa'l 'Adl' (people of unity and justice). As against the orthodox, they tried to uphold the unity and justice of God above everything. Wāṣil bin 'Aṭā' the forerunner of 'Allāf and the founder of the sect led the reaction against the crude fatalism of the orthodox and in course of time these two problems gave birth to many other sub-problems such as the nature of matter, the relation between essence and existence and so forth.

These conceptions however underwent further modifications, until the view of unity held by the Mu'tazalites became a mere abstract possibility about which nothing could be predicated. Abū Hāshim goes so far as to say that we cannot attribute even knowledge to God,[6] for His knowledge must be in Himself (or otherwise). The first necessitates the identity of subject and object which is absurd, the second implicates duality in the nature of God which is equally impossible.[7]

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[5] *Shahrastani*, Cureton, p. 34.

[6] *Ibid.*, p. 48.

[7] *Dev. Met. in Persia*, Iqbal, p. 50.

We may, at this stage, see an example of the way in which the Mu'tazalites tried to bring reason and Revelation or Aristotle and the Qur'ān into conformity with each other. Aristotle's position with regard to the Universe is that it exists from eternity, but the Qur'ān is explicit on the point that it was created. Now, they tried to harmonize the two positions by maintaining that ' it existed eternally, but in perfect quiescence and stillness, as it were latent and potential rather than actual, and without those qualities which appear in the categories of Logic and are to us the only known terms of existence. Creation meant that God brought in movement so that things began to exist in time and space. . . .'[8]

We may consider briefly the position of the more important thinkers among the Mu'tazalites because it was the legacy left by them that gave rise to the Anti-Aristotelian reaction. Having briefly discussed the position of 'Allāf, we may now pass on to the celebrated Naẓẓām,[9] a disciple of the said 'Allāf. He was an encyclopaedic writer (d. 231) and a devoted student of Greek philosophy.

Being an advocate of Free Will and the objective standard of good and evil in the case of God, he was confronted with an objection that if the objective standard of good and evil is maintained for God, it means that His own actions are determined, because, in accordance with the Mu'tazalite position, God does not will anything contrary to good and therefore his acts are not free but determined. This restriction, Naẓẓām admitted in the case

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[8] O'Leary: *Arabic Thought*, p. 125.

[9] For a full account of Naẓẓām's position see, *Al-Farq bain al Firaq* by Ṭāhir Baghdādī, *Kitābal Ansab* by Ṣam'ani, *Milil wal Nihal* by Shahrastani, Ibn Hazm, and Yehya Zaidi, *Murujal Dhahab*, etc.

of God, but held that it was only a restriction in potentiality not in actuality, God being restricted by His own nature.

He taught the infinite divisibility of matter and obliterated the distinction between substance and accident.[10] Existence, he regarded as a quality superimposed by God on the pre-existing material atoms which would have been incapable of perception without this quality. Substance, he maintained to be a collection of qualities—taste, odour, colour—which in themselves are nothing more than material potentialities. The soul, too, is a finer kind of matter, and the processes of knowledge are mere mental motions. Creation is only the actualisation of pre-existing potentialities (Tafra.)[11]

Bishr bin al Mu'tamir is the next figure we come across in our present inquiry. For him, as well as for Al 'Aṭṭār Baṣarī, colour, length, breadth, taste or smell are all the activities of bodies themselves and not created by God. Mu'tamir explains the properties of bodies and the serial connection between actions and their resultants by what he calls 'Tawallud.'[12] The position of these thinkers has therefore been summed up by Iqbāl in the following words: 'Rationalists were philosophically materialists and theologically Deists.' We might quote another passage from the same author to show their treatment of atomism, which he takes from *Kitāb al Masā'il fi 'l khilāf bayn al-Baṣrīyyīn wa'l Baghdādīyyīn*. To them, substance and atom are identical, and they define substance as a space filling atom which, besides the quality of filling space, has a certain direction, force and existence forming its very essence as an actuality. In shape it is square-like; for if it is supposed to be circular, combination of different atoms would not

[10] *Shahrastani*, Cureton, p. 38.

[11] *Ibid*, p. 38.

[12] *Ibid.*, p. 44.

be possible. There is however a great difference of opinion among the exponents of atomism in regard to the nature of atom. Some hold that atoms are all similar to each other; while Abu'l Qāsim of Balkh regards them similar as well as dissimilar. When we say that two things are similar to each other, we do not necessarily mean that they are similar in all their attributes. Abu'l Qāsim further differs from Naẓẓām in advocating the indestructibility of atom. He holds that the atom had a beginning in time but that it cannot be completely annihilated. The attribute of 'Baqā' (continued existence), he says, does not give to its subject a new attribute other than existence; and the continuity of existence is not an additional attribute at all. The divine activity created atom as well as its continued existence. Abu'l Qāsim, however, admits that some atoms may not have been created for continued existence. He denies also the existence of any intervening space between different atoms, and holds unlike other representatives of the school, that the essence or atom (Māhīyyat) could not remain essence in a state of non-existence. To advocate the opposite, that an essence (which is essence because of the attribute of existence) could remain essence in a state of non-existence, is to say that the existent could remain existent in a state of non-existence. It is obvious that Abu'l Qāsim here approaches the Ash'arite theory of knowledge which dealt a serious blow to the Rationalist theory of matter.[13]

Next we may consider the position of Ma'mar who holds the attributes of God as only negative conceptions. When He is said to be infinite, it means that He is unlimited in space, or by saying eternal it is meant only that He is not limited in time. However this thinker tends towards Pantheism.

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[13] *Dev. of Met. in Persia,* Iqbal, pp. 53-55.

Tumāmah b. Ashras and Al Jāḥiẓ represent sceptic tendencies and the former denies God as having created the Universe through an act of volition. His position displays two-fold tendencies—Scepticism and Pantheism—the former carried further by Al Jāḥiẓ and the latter by the Sūfīs.

Al Jāḥiẓ regards will as simply a manner of knowing and so an accident of knowledge; a voluntary act he defines as one known to its agent.

The Mu'tazalite school of Baghdād concerned itself mainly with the metaphysical question "What is a thing?" and that of Basrah carried on further discussions over the attributes of God.

The Mu'tazalite ascendency comes to a close with Abū 'Alī al Jubbā'ī and Abū Hāshim giving place to the Ash'arite system of Thought started by Al-Ash'arī, which we shall consider in the next chapter.

CHAPTER II

Al-Ash'arī and the Ash'arites.

The Beginning of Reaction.

With Al-Ash'arī, Islamic thought enters a new era, and a full-fledged reaction against too ready an acceptance of Aristotelianism comes forth with full force.

Abu'l Ḥasan al-Ash'arī, was born at Baṣra in 260 A.H. and, until his fortieth year, he was a zealous pupil of the Mu'tazalite theologian al-Djubbā'ī, then on the occasion of a dispute with his teacher on the fitness of God's predeterminations, disagreed with him and went his own way. But Spitta has shown that we have to do here with a biassed legend and that probably the study of the traditions elucidated for him the contradiction between the

Mu'tazalite views and the spirit of Islam. However that may be, he henceforth championed the orthodox views against the Mu'tazalites and composed a large number of works of a dogmatic and polemic nature. Ibn-i-Furak states that their number amounted to about 300. Ibn-i-'Asākir gives the titles of 93 of them which are repeated with occasional notes in Spitta's Zur Geschichte Abul Hasan al Asari's, p. 63 et seq. Only a few of them have been preserved and are enumerated by Brockelmann. Gesch. der Arab Litter. 1. 195 . . .'[14]

"The movement initiated by Al-Ash'arī," says Iqbāl, "was an attempt not only to purge Islam of all non-Islamic elements which had quietly crept into it, but also to harmonise the religious consciousness with the religious thought of Islam. Rationalism was an attempt to measure reality by reason alone; it implied the identity of the spheres of religion and philosophy, and strove to express faith in the form of concepts or terms of pure thought. It ignored the facts of human nature, and tended to disintegrate the solidarity of the Islamic Church. Hence the reaction.[15]

The story of his conversion from the Mu'tazalite to the orthodox view has been given by Ibn-i-Khalikān in the following words. 'Al-Ash'ari was a Mu'tazalite in the beginning, then he denounced the doctrines of Justice and the Creation of Qur'ān in the Jami' Masjid of Baṣrah on Friday. He publicly declared in the following manner, 'Those who know me know who I am, as for those who do not know me, I am so and so, the son of so and so; I used to hold that the Qur'ān was created and that eyes shall not see God and that we ourselves are the authors of our evil deeds; now I have come back to the right view and now I

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[14] *Ency. of Islam*, pp. 480-81.

[15] *Dev. of Met. in Persia* by Iqbal, pp. 66-67.

take upon myself to refute these doctrines and expose the weaknesses and the infamy of the group.'[16]

Since then he spent his whole life in writing polemical treatises against the Mu'tazalites. Some of his well-known works are—Kitāb al Sharḥ wál Tafṣīl, Luma', Mu'jaz, Idāh al Burhān, Tabyīn, Al-Ibanah'an Uṣūl al Dayānah, al-Istiḥsan fi'l khawḍ al Kalām, Maqālāt al Islāmīyyīn, and Maqālāt al Ghairal Islāmīyyīn.

He succeeded in gathering round him a number of scholars who developed and spread his doctrines throughout the greater part of Islamic world. He gathered round him followers like Abū Sahl Sa'lūkī, Abu Qaff'āl, Abū Zayd, Abū Bakr Jurjānī, Abū Muḥammad Ṭabarī and many others of great learning and repute. These were the immediate followers of Al-Ash'arī, but the later followers, most notable being Bāqilānī, Isfrā'inī, Ibn-i-Furak, al-Qushairī, al-Juwainī (Imāmal Ḥaramain) and lastly the great al-Ghazzālī, were men of high capabilities and it was through these people that al-Ash'ari's system gained ground in nearly all the Islamic countries.

In the beginning there was a great opposition from certain quarters as the system maintained a compromise between the strictly orthodox views and the absolutely unfettered thought of the latter Mu'tazalites like al-Jāḥiẓ and Ibn-i-Ashras. Out of the four schools of Fiqh in Islam, namely the Ḥanafite, the Shāf'iite, the Mālikite and the Ḥanbalite, it was in the Shāf'iite camp that it was most appreciated in the beginning. 'The Ḥanafites preferred the Māturīdī doctrines and the Ḥanbalites kept to the old point of view. In Spain, Ibn Ḥazm opposed the Asha'rite doctrines. Under the first Seljuk Tughrul Beg, the distinguished Asha'rite teachers were even persecuted at the instance of the Wazīr al Kunduri; however his

[16] *Ibn-i-Khallikān*, pp. 326-327.

successor Niẓāmul Mulk put an end to this treatment of them.'[17]

This was the state of affairs in the beginning, but by and by the Ash'arites began gaining ground and due to the capabilities of its adherents, the Asha'rite system in a short period prevailed over all existing systems. In Spain also, Ibn Tumart, the so-called disciple of al-Ghazzālī, did a great deal for the spread of this system of thought.

Let us now consider the contribution made by these theological philosophers towards Islamic philosophy. We have already seen the position Islamic philosophy had reached when the Ash'arites came in the field. The burning topics of these days were (1) the attributes of God, the Freedom of Will, the nature of substance, the theory of causation and the relation between essence and existence, with regard to all of which we have briefly considered the position of the Mu'tazalite thinkers.

The problem of the attributes of God was the upshot of the purely theological question whether the word of God existed with Him or was created. In opposition to the Mu'tazalite view, the Asha'rites held up the theory of the attributes of God. There is a Mukhālafah, they maintained, amongst the numerous attributes of God. By this they meant that when we use a certain quality, say wisdom, for God, we ought not to mean anything by it that could be predicated of human beings. The attributes predicated of God should not be applied to men and if applied they must be predicated in a different meaning. By God's being wise is meant that He possesses this particular attribute in a way which cannot be predicated of men. The difference of meaning, they demand to be maintained, is not only quantitative but is qualitative as

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[17] *Ency. of Islam*, p. 481.

well. That is, by saying that God is wise in a sense different from what we mean when we use the same adjective for man, we should not mean that God possesses wisdom much more than man.

This problem led to the closely related question of essence and existence and the Ash'arites maintain that the essence and the existence of God are identical. God is the ultimate necessary existence 'carrying its attributes in its own being.' They discarded the Aristotelian list of categories, rejecting eight of these as merely *i'tibārī* (relative) subjective in the mind of the knower, and having no objective reality at all. They maintained only two—existence and attribute—as objectively real. And in some of the Ash'arites we find even attributes being reduced to purely subjective relations.

Their theory of knowledge was an achievement which has made them the precursors of Berkeley and Kant, as we shall presently see. To answer the question, "What a thing is?' they subjected to a searching criticism the Aristotelian categories of thought, and arrived at the conclusion that bodies have no properties in themselves. They made no distinction of Primary and Secondary qualities of a body and reduced all of them to purely subjective relations. Quality too became with them a mere accident without which the substance could not exist. They used the word substance or atom with a vague implication of externality; but their criticism reduced the Universe to a mere show of ordered subjectivities which, as they maintained like Berkeley, found their ultimate explanation in the will of God. In his examination of human knowledge regarded as a product and not merely a process, Kant stopped at the idea of '*Ding an sich*,' but the Ash'arite endeavoured to penetrate further and maintained, against the contemporary Agnostic Realism, that the so-called underlying essence existed only in so far as it was brought in relation

to the knowing subject.'[18] Thus they reached a position whch maintained a perpetual annihilation and creation of atoms every moment. When a ball moved from one position to another, the atoms at every position are created and annihilated.

The world consists of atoms on which the percipient mind projects the qualities that do not inhere in the thing. 'Against the Aristotelian theory that matter suffers the impress of form, he (the Ash'arite) argues that all impress is subjective in the mind; if all qualities fall out, substance itself ceases to exist; and so substance is not permanent but transitory, which opposes the Aristotelian doctrine of the eternity of matter.'[19]

The views of the Ash'arite on the theory of causation are still more original and opposed to the Aristotelian conception. The immediate cause of all change, the Ash'arite holds, is God and there are no secondary causes. They deny any ordered law in nature and reject the theory of causation. Every phenomenon is caused by the will of God directly. Thus fire does not cause burning, but God creates a being burned when fire touches a body and the burning is directly caused by Him. Thus in the views of the Ash'arites with regard to the theory of causation, we find a gradation ultimately coming into a full-fledged scepticism.

As to the problem of Free Will they tried to synthesize between the two opposing schools of thought—the orthodox and the Rationalists (Mu'tazalites). The former held determinism and the latter libertarianism. The Ash'arite tries to chalk out a middle path and to compromise between the two. God, he holds, creates power in man and gives him the choice, then He creates the act in correspondence

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[18] Iqbal, *Dev. Met, in Persia*, pp. 70-71.

[19] O'Leary, *Arabic Thought*, p. 216.

with this power and choice. Thus the action is acquired by 'Kasb' (acquisition).

Some of the later Ash'arites, notably Imām-al-Rāzī, however left this middle position, and perhaps eager to maintain the extreme position against the Mu'tazalites, upheld determinism and tried to support it most enthusiastically. But we must remember that the position of the Ash'arites as a school of thought is neither free will nor determinism but a course midway between the two.

The rise and growth of atomism in the Ash'arite system is a fair indication of a revolt against the Aristotelian conception of a fixed Universe. The Quran says, 'God adds to his creation whatever he Wills.' Taking their inspiration, perhaps from this verse, they reached a position which is amazingly modern. The world, they hold, is formed of indivisible atoms, which are perpetually coming into existence, and thus the Universe is not fixed once for all.

Time and Space.

The Ash'arites hold that each atom occupies a position which does not involve space. That being so, what is the nature of motion which we cannot conceive except as the atoms' passage through space. Since the Ash'arites regarded space as generated by the aggregation of atoms, they could not explain movement as a body's passage through all the points of space intervening between the point of its start and destination. Such an explanation must necessarily assume the existence of void as an independent reality. In order, therefore, to get over the difficulty of empty space, they resorted to the notion of 'Tafra' or jump; and imagined the discrete positions in space, as jumping over the void between one position and another. Thus according to these thinkers,

a quick motion and a slow motion possess the same speed; but the latter has more points of rest. I confess I do not quite understand this solution of the difficulty. It may however be pointed out that modern atomism has found a similar difficulty and a similar solution has been suggested. In view of the experiments relating to Planck's theory of Quanta, we cannot imagine the moving atom as continuously traversing its path in space. 'One of the most hopeful lines of explanations,' says Professor Whitehead in his *Science and the Modern World*, 'is to assume that an electron does not continuously traverse its path in space. The alternative notion as to its existence is that it appears at a series of discrete positions in space which it occupies for successive durations of time. It is as though an automobile moving at the average of 30 miles an hour along a road did not traverse the road continuously, but appeared successively at the successive milestones remaining for two minutes at each milestone.'[20]

The Ash'arite conception of time is just in accordance with their conception of space. Between every two moments of time they posited a void even as they did in the case of two positions of space. Apart from considering how far the view is tenable, we may just see similar movements of thought in our modern science and give these early thinkers the credit of having reached a position towards which even modern science is inclined. "Contrary to the ancient adage, *Nature non facit saltus*, it becomes apparent that the Universe varies by sudden jumps and not by imperceptible degrees. A physical system is capable of only a finite number of distinct states. Since between two different and immediately consecutive states, the world remains motionless, time is suspended,

[20] Iqbal, *Reconstruction of Religious Thought in Islam*, p. 96.

so that time itself is discontinuous : there is an atom of time."[21]

Thus far, we have nearly considered all the main points of the Ash'arite system with special reference to Anti-Aristotelian tendencies.

CHAPTER III

AL-GHAZZĀLĪ AND THE LATER ASH'ARITES

Al-Ghazzālī stands out a unique personality among the long line of Islamic thinkers, as it was he that gave Islamic thought a flexibility which enhanced for it the possibilities of adapting itself to different trends of thought and yet maintaining its identity as such. There is a common opinion about Ghazzālī, that by a refutation of falāsifah he brought an end to philosophical speculation in the Islamic world. But the fact is just the opposite. He gives a new turn to the two main branches of Islamic thought—Theological Philosophy and Mysticism. His contribution towards the two, has introduced a new era in both. History of Sufism as well as of Kalām (Theological Philosophy) take a new turn with Al-Ghazzālī.

Before starting upon an investigation into the contribution he made towards the purging of Islamic thought from Aristotelian influences, we may briefly consider his life. A perusal of the life of Al-Ghazzālī is more important than that of most other thinkers, for, as Macdonald says, 'Al-Ghazzālī's theological position sprang directly from his spiritual experiences, so the best introduction to an understanding of that position is the study

[21] Rongier, '*Philosophy and Physics*,' (quoted in *Reconstruction of Religious Thought*), p. 103.

of his life.'[22] And the study of his life is more interesting and useful on account of the fact that he has given his own biographical account in Al-Munqidh min al ḍalāl, which 'is essentially an *Apologia pro vita sua*, a defence of his life as a mystic against all his assailments, theological and philosophical, and in its autobiographic element may stand beside that of Newton.'[23]

He was born at Ṭahirān, a town in the district of Ṭūs in the year 450 A.H. Another tradition relates that he was born at Ghazalāh, a village in the district of Ṭūs, but this is not reliable as there is no such village in Ṭūs.

His father being no literate person was yet very anxious to educate his sons, and while in death-bed he entrusted both of his sons to a friend in order that he might see his way to get them educated.

After the fashion of the age, he received his early education under theologians and studied Fiqh, with Aḥmad b. Muḥammad Radhakānī. Being a true seeker of learning he went from place to place seeking after authorities on different subjects till he found the celebrated Imām al Ḥaramayn, the well-known Ash'arite theologian of the age and soon won the favour of his teacher. It is related of his teacher that though he spoke of his promising pupil very highly, yet at heart he was jealous of his high attainments. But perhaps the fact is that this feeling on the part of the Imām was due to the independence of thought and a contempt for authorities based on too much of self-reliance.[24]

Afterwards he went to Baghdād and was appointed as a lecturer in the Niẓāmīyyah Madrasah where he remained till 488.

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[22] *Journal of the American Oriental Society*, Vol. XX, page. 73.

[23] *Journal of American Oriental Society*, Vol. XX, p. 74.

[24] *Tabaqat al Shāfi'īya*, Vol. IV, pp. 107-108.

All along his career as a lecturer he had been studying philosophy privately in order to understand his own position.

In 488 Al Ghazzālī 'went to Syria and visited Jerusalem and left off teaching at Niẓāmīyyah, entrusting it to his brother, and gave himself to devotion and wore coarse clothing and ate poor food. And in this journey he composed the Iḥya'-al-'Ulūm al Dīn and many people heard it from him in Damascus, and he returned to Baghdād after performing the pilgrimage in the following year and went to Khurāsan.'[25]

Thus he spent eleven years in philosophy, meditation and mystic practices, studying the positions of all the surrounding and prevalent sects. Having completed this period of life, he was for certain reasons compelled to re-start lecturing at the Niẓāmīyyah Madrasah, a job which was now thrust upon him against his own liking. However he did not continue long in this position and retired for the second time in 500 A.H. after the death of Niẓām al Mulk.[26]

During the last 5 years of his life he busied himself with the study of Ḥadīth.[27]

He died on Monday Jamadī al Thānī 505 A.H.[28]

A study of the different systems of contemporary thought and his inquisitive disposition tended to generate in him a sceptic tendency. He began to doubt the self-evident and fundamental truths upon which the whole architecture of human knowledge stands and much like Descartes, the father of modern philosophy, subjected these to a critical search. His Ihyā' al 'Ulūm' has so remarkable a resemblance to the '*Discourse sur la methode*'

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[25] *Ibn al Athir*, Vol. X, p. 104.

[26] *Sharh Ihya al Ulum*, p. 19.

[27] *Subki. Tabaqat*, Vol. IV, p. 109.

[28] *Ibid.*, p. 110.

of Descartes, that had any translation of it existed in the days of Descartes, every one would have cried against the plagiarism.[29] He anticipated Descartes, and in the words of Macdonald, 'Seven hundred years before Hume cut the bond of causality with the edge of his dialectic.'[30]

He was brought up in childhood under the care of a mystic and educated later on by the Ash'arite doctors of theology. The two threads thus ran together and we find that in the legacy of thought left by him the two are interwoven. Legally speaking, he was an Ash'arite, but a man of genius like him could not blindly follow a creed in all its essentials. He gave a new turn to the Ash'arite system by introducing elements of Sufism into it, and the same to Sufism by bringing it under a scientific system. He synthesized the two in such a perfect harmony that since then they have retained the interfusion and do yet retain.

The spiritual unrest which goaded him at every moment of his life, was changed at last into a sort of quietism and he found the ultimate solace in mysticism.

Till now the ultimate principle in Islamic thought had been intellectualism as opposed to Intuitionism. No doubt there had been Sufis, but they were not philosophers. It was Al-G͟hazzālī who for the first time in the history of Islamic thought attempted to prove the superiority of the intuitive over the purely intellectual mode of knowledge.

The different stages in his life reveal the fact that he was never at rest with any position till he came to mysticism. Dissatisfied with the crude and blind faith of the orthodox, he began studying philosophy and composed a book entitled 'Maqāṣid al Falsifah.' But again dissatisfied with the position reached, he began refuting

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[29] Lewi's *History of Philosophy*, Vol. II, p. 50.

[30] *Journal of the American Oriental Society*, Vol. XX, p. 103.

the doctrines exposed there and wrote Tahāfat al Falsifah (a refutation of the falsifah) from the Ash'arite point of view. Still dissatisfied with the Ash'arite position, which he held as most indispensable for the multitude but not fitted for a thinker, he took to mysticism.

Reason, till now was the best and most reliable instrument for acquiring sure knowledge but with Al-Ghazzālī, intuition and revelation got the upper hand. Philosophy was subordinated to mystic experience. He posited gradations of religion in proportion to the intellectual and spiritual development of man. For the masses, religion as a blind acceptance without demanding a rationale of it, for the intellectually more developed it was religion as revealed, but capable of being tested and justified on rational principles. For the initiated Sufi—face to face with reality—no rational justification was required for the verities experienced by him.

Post-Ghazzalian Ash'arites

Among the post-Ghazzalian Ash'arites only three names stand out most prominent,—those of Muḥammad b. 'Abdal Karīm al Shahrastānī, Fakhral Dīn al Rāzī, and Saif al Dīn Āmidī. Shahrastānī was born in 479 A.H., studied Fiqh, Usūl and Kalām and went to Baghdād in 510 A.H. where he was highly welcomed. He is the author of several books—Nihāyat al Aqdām fi'l 'Ilm al Kalām, Al Manāhij wa'l bayān, Talkhīsal Aqsām li madhāhib al anām, but the composition which has immortalised his name is ' kitāb-al-milal wa'l nihal ' in two volumes. This is an indespensable book for any student of Islamic philosophy, but is expository rather than critical.[31] There is little by way of original contribution to Anti-Aristotelian

[31] For a full account see *Ṭabaqāt al Shafi'iya* & *Ibn-i-Khallikān.*

thought which may bring him any credit. Being staunch Ash'arite and a student of philosophy he takes up the position of his school reached by now and gives his own justification for the same.

The next personality is that of Imām Fakhr-al-Dīn Rāzī, born 29 years after the death of AlGhazzālī. He is one of the greatest personalities of Islam, yet about his philosophical merits there is a difference of opinion. The reaction that had begun with Al-Ash'arī and had developed itself into a regular revolt by the time of Ghazzālī, found a strong hand in Rāzī.

Being one of the most learned theologians Islam has ever produced, and a scholar of Philosophy as well, he undertook to refute the Mu'tazalite's and the falasifah's position so vehemently as even sometimes going out of the creeds of his own school. He tried to refute the position of the followers of Aristotle to such an extent that if he did not deny the truth of the conclusion, he at least attempted to expose the weakness and untenability of the processes of reasoning adopted by them. He was strongly opposed by Muḥaqqiq Ṭūsī and Bāqar Dāmād who upheld the Mu'tazalite views.[32]

It is noteworthy about him to mention that in his zeal for refuting the Aristotelians at every point he swang to the Pre-Ash'arite orthodox view of Determinism. He gave up the notion of ' acquisition ' or kasb[33] invented by the earlier Ash'arites in order to chalk out a path midway between Libertarianism and Determinism.

His work, however, is the best defence of orthodox theology of Islam on philosophical grounds and with him the line of eminent Ash'arite thinkers practically comes to a close.

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[32] Shibli, *Al Kalām*, p. 71.

[33] *Ibid.*, 72.

Out of the numerous books he wrote, Maṭālib-al 'Āliyah, Nihāyat al 'Uqūl, Arba'īn fī usūl al Dīn, Muḥṣal, Albayān wa'l Burhān, Mabāḥi<u>th</u>-i-Mashriqīyyah, Tah<u>dh</u>ib al Dalā'il, Tāsīs al Taqdīs, Irshād al Naẓar ila Laṭāif al asrār, Ajūbat al masā'il al Najjārriya fi sharḥ Asmāi' Ilāhi-wa'l ṣafāt, kitāb al Qaḍā wa'l qadr, Ta'jīz al Falāsifah, 'Aṣmat al Anbiya', kitābal <u>kh</u>alq wa'l ba'<u>th</u>, <u>kh</u>amsīn fi 'usūl al Dīn, Sharḥ Ishārāt and Mabāḥi<u>th</u> Mashriqīyya are more renowned. He is best known for his most voluminous commentary of the Qur'ān entitled Tafsīr-i-kabīr.[34]

Then we come to Al-'Āmidī with whom the line of the Ash'arite thinkers comes to to an end and after whom we find men like Taftāzānī and Aḍud al Dīn taking up the refutation of Aristotelian thought and defending the Ash'arite views but without any thing characteristic of their own.

Āmidī[35] was born in 551 A.H. and took his early education in Fiqh and Usūl at Baghdad and in Philosophy in Syria. In his works, we do not find a blind acceptance of the hitherto reached Ash'arite position. He sometimes criticizes the position of the earlier Ash'arites and holds his own against them, yet there is no such improvement upon the general Ash'arite position as to deserve a detailed consideration. He refutes Aristotelianism in his own way and most freely. Three of his books are well known: Daqā'iq al Ḥaqā'iq, Rumūz al Kunūz, and Abkār al Afkār.

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[34] For a fuller account see *Lisan al Mizan, Aksir fi' Usūl al Tafsīr, <u>Dh</u>ahbi's Mīzān, Ibn-i-<u>Kh</u>allikān* and *Ṭabaqāt al Aṭibbā.'*

[35] For a fuller account see *Ṭabaqāt al Aṭibbā, Ṭabaqāt al Shāfi'iyyah* and *Ibn <u>Kh</u>allikān.*

CHAPTER IV

The Ẓāhirites'—Ibn Ḥazm & Ibn-i-Tayimiyah[36]

With the exception of the solitary figure of Ibn Ḥazm we do not find any body in Spain taking seriously to a philosophical defence of Muslim Theology till the beginning of the 6th century A.H. when Ibn-i-Tumart, the famous disciple of al-Ghazzālī popularized the view of his teacher. The reason for this has been given by Ibn-i-Ḥazm himself in a tract in praise of Spain, wherein he says " As there are not different sects in our country, and neither controversies are held on religious dogmas, so al Kalām does not flourish here as other subjects do. However, some Mu'tazalites, *e.g.*, Khalīl b. Isḥāq, Yeḥyā b. Al Samānīyyah, Mūsā and Aḥmad have written certain books on this subject. I myself have written several books in defence of my traditionistic views."[37]

Ibn-Ḥazm was born at Cordova in 384 A.H. and received his early education in Fiqh and Ḥadīth, and afterwards studied philosophy with Muḥammad b. Ḥasan Kanāni, unlike his fellow countrymen, as it was not safe in those days to study philosophy in Spain. But Ibn Ḥazm did not care about it and learnt, to his satisfaction, logic and metaphysics with great interest.

His works have been enumerated, perhaps exaggerated, by some as totalling to about 400 containing 80,000 pages. He is best known through his celebrated work Al faṣl fi'l milal wa'l ahwā' wa'l nihal, wherein he has given an exposition as well as a criticism of the creeds of the Christians, Naturalists, Magians and Falāsifah (Aristotelian

[36] Under the heading Zahirite, Ibn Tayimiyah ought not to have legally been included, but I believe it was the legacy of this school which he carried to its extreme.

[37] *Nafhal Tib.*, p. 120.

Thinkers). This is a very valuable work and, like Shahrastāni's Milal wa'l Nihal, is indispensable as a history of Islamic thought. Yet it stands unique in respect of the fact that it gives a criticism as well as an exposition of all contemporary views on theology and philosophy.

Ibn-i-Taimiyah, a great figure in the Post-Ghazzalian development of Islamic Thought, was born in 661 A.H. at Harrān. A man of thoroughly independent views he rejected Taqlīd and declined to follow any of the four recognised schools of Fiqh. It was, however, the legacy left by Dā'ūd Ẓāhirī and Ibn Ḥazm that influenced him most. A man of great talents and energies, he devoted himself to the task of freeing Islam from all non-Islamic influences and restoring it the pristine simplicity of its early days. As a part of this wider work, he took upon himself the refutation of falāsifah (Aristotelians) which he very well did, at least in so far as Greek logic is concerned. Al-Radḍ'alā al Manṭiq is one of the greatest contributions towards Anti-Aristotelian Thought in Islam.[38] His writings amount to about 8,000 pages which give a life average of about 40 pages a day.

We should however confine ourselves to an examination of some of the books written in refutation of falāsifah. He writes in Kitābal 'Aql wal Naql as follows:—

The Aristotelians are blind followers of Aristotle, imitating him in whatever he said on physics, logic and metaphysics. Some of them know by their discretion that Aristotle is absolutely on the wrong way; but merely on account of a high regard for him, never care to oppose him, though many thinkers have proved beyond doubt that

[38] The book has not yet been printed. Manuscript copies of it are to be found in the Dāral Muṣannīfīn A'ẓamgarh, Nadwatul 'Ulemā' Lucknow, Ḥyderabad and Sind libraries.

Aristotelian logic contains indefensible mistakes.[39] Further he says :—

There is no end to the differences of opinion among the falāsifah themselves. . . . Abū Bakar Bāqilānī, in his Kitāb al Daqā'iq, has quoted some of these and refuted the falāsifah. . . . He (Bāqilānī) has perferred the logic of the 'Arab Mutakallimīn to that of Aristotle. Likewise, the Mu'tazalite and the Shi'ite Mutakallimīn have refuted the positions of many of these falāsifah . . . . Ghazzali has refuted this system in Tahāfat al falāsifah, after giving an exposition of the same in Maqāṣid al Falāsifah. . . Abu'l Barakāt, the author of Kitāb al Mu'tabar, also criticizes this system in his book. . . Rāzī and 'Āmidī, as well, criticize the views of the Peripatetics. Even Ibn Sīna at certain places refutes the Aristotelian system and in the Shifā' he writes that he has given his own position in Al-Ḥikmat al Mashriqīyyh. Suharwardī has done the same in his Ḥikmat al Ishrāq[40]

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Milal Wa'l Nihal : Ibn Ḥazm.

Al Farq bainūl Firaq : Baghdādī.

Milal Wa'l Nihal : Murtaḍā.

Tārikh al Misr : Maqrīzī

Murūj al Dhahb : Mas'ūdī.

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[39] Kitāb al 'Aql wal naql, manuscript copy at A'ẓamgarh, pp. 85-86.

[40] *Ma'ārif*, Feb. 27, Vol. 2, No. 15.

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THE ROLE OF REASONING IN ADVAITA PHILOSOPHY

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An implicit faith in Revelation with its consequent distrust of independent thought, it is well known, is claimed to be the privilege of the orthodox systems of Indian philosophy in general and of the Vedānta school in particular. Historically, this condemnation of reasoning or *tarka* is at least as old as the Upaniṣads which, as is particularly evident from the well-known verse of the Kaṭhopaniṣad, placed the ultimate reality entirely beyond the ambit of reasoning and argumentation. Śaṅkara's distinction between Reality regarded from the *pāramārthika* or eternal standpoint and Reality as it is for the human finite understanding—a distinction which is essentially a reproduction of the Buddhistic distinction of *paramārtha* or *parinispanna* knowledge from what is merely *lokasaṁvṛtisatya* or *paratantra*—breathes the selfsame agnostic attitude that limits the powers of human thinking and other faculties of knowledge to the world of ordinary experience alone. The Absolute, it is reiterated in diverse contexts, is unknowable and unthinkable and is purely *śabdamūla* and *śabdapramāṇaka;* and Śaṅkara, far from considering it as an unphilosophical attitude, declares irrational reliance on Revelation to be at the root of the evidential superiority of his own position to the rationalistic systems of philosophy.[1]

[1] *Vedāntavākyānāmaidamparyaṁ nirūpayituṁ śāstraṁ pravṛttaṁ na tarkaśāstravat kevalābhiryuktibhiḥ kañcitsiddhāntaṁ sādhayituṁ dūṣayituṁ vā pravṛttaṁ*—Ś.B. II. 2. 1.

So far Śaṅkara's position is analogous to modern agnosticism, such as is illustrated in the systems of Kant and Spencer, which restricts human knowledge without questioning its objective validity within the world of ordinary experience investigated by science. Kant, for instance, despite his limitation of scientific knowledge to the phenomenal world, vindicated the claims of science, against the sceptical conclusions of Hume, to offer universal and necessary truth. Śaṅkara, however, has also a sceptical tendency, and his misology, when judged in the light of some of his express statements, knows no bounds. The instability of reasoned knowledge, according to them, is not due to the pretension of reason to step beyond the limits of the phenomenal world; it is, on the contrary, inherent in the very nature of human reason. Reasoning, in so far as it is independent of traditional authority (*nirāgama*), has nothing to check its immethodical desultoriness, and, consequently, a reasoned conclusion, howsoever carefully obtained, cannot be placed above the risk of refutation by a more powerful dialectician. The defect, it is said, is inherent in human reason which is different for different men (*puruṣamativairūpyāt*), and it vitiates all conclusions obtained through independent thinking.[2]

The obvious objection to this unqualified condemnation of all reasoned knowledge, as he sees clearly, is that the very instability of reasoning has to be established on the basis of reasoning itself. The second objection which he

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[2] *Utprekṣāmātranibandhanāstarkā apratiṣṭhitā bhavanti*—S. B. II. 1. 11. This universal scepticism in regard to the efficiency of independent reasoning is more pronounced in Śaṅkara's commentary on the Kāṭhakopaniṣad I. 2. 8, where private judgment is condemned as vitiated reasoning or *kutarka* without a particle of stability in respect of any object of enquiry. In the S. B., however, Śaṅkara appears to shudder at his own shadow and discovers that universal scepticism refutes itself.

anticipates is that universal scepticism would make life impossible which is based on our ability to infer the future behaviours of things. Thirdly, the real meaning of the Scripture which is to sit in judgment upon reasoned knowledge has to be collected out of the evidently contradictory statements of the Scripture and this itself requires reasoning. Lastly, it is not reasonable to infer the instability of reasoning from the different conclusions so far attained, for, the fallacies of the earlier generations may be removed by the more careful reasoning of a later age. Out of these possible objections to the theory of universal scepticism, the first and the third are evidently of a formidable character, and their formidableness is appreciated by Śaṅkara himself who hastens, in reply, to acknowledge the finality of reasoning in certain cases only. And then in place of a universal scepticism which dominates his imagination, he contents himself with a modified agnosticism of some sort. This, however, does not turn the point of criticism. When the question is one of reconciling universal scepticism with itself, it is no answer to say that reason sheds unfaltering light on certain topics. And, similarly, when the problem is to ascertain how, if no reasoning has an independent authority, a particular interpretation of the scriptural statements represents their real, as distinct from the apparent, meaning, it is idle to refer to an imaginary consensus of opinions of all interpreters. If the Veda is the source of right knowledge, and if the consensus of opinions of all rationalists who have ever sought to interpret the Veda be regarded as sufficient for understanding its real meaning, then certainly right knowledge is unattainable even by Śaṅkara whose interpretation has not stood the test he himself offers for distinguishing the perfect knowledge from the imperfect. The consensus of opinions being itself the point at issue, it cannot be appealed to in vindication of the scriptural authority. The Scriptures

may shine in their own light as Śaṅkara would have his readers believe; but in what particular light they will shine upon a particular interpreter depends largely on the inner light which he brings with himself.

Though, however, Śaṅkara has failed to justify the validity of his own interpretation of the Scriptures, his condemnation of the human faculties of knowledge, when viewed in the light of some of his expressed opinions, continues steady and undisturbed throughout his exposition. The Absolute, it is said, is too deep for our faculties and, consequently, falls beyond their scope, and reasoning in respect of the Absolute must, therefore, be conducted under the control of the Scriptures. So far, then, there seems to be ample justification for the opinion, widely shared by the exponents and critics of Śaṅkara, that "Śaṅkara's apparent abdication of private judgment, his reliance on instruction imparted by another, and his abhorrence of unfettered thought, are disconcertingly suggestive of the narrowness of European medieval philosophy, and seem to place a deep chasm between Vedantic and modern speculation."[3] This opinion has been expressed almost in an epigrammatic style by another accomplished scholar of our time who remarks that Śaṅkara "does not accept the authority of logic as a means of congnising the Absolute, but he deems it a privilege of the Vedānta to fare without logic since he has Revelation to fall back upon."[4]

There is, however, another side of the shield. While professing an undiluted abhorrence of pure reason, Śaṅkara does not fail to cut out by-paths for letting in the light of reason; and the result is that his philosophy, far from reducing itself to a mere catalogue of dogmas, has the

[3] Principal W. S. Urquhart, *The Vedanta and Modern Thought*, p. 78.

[4] Dr. T. Stcherbatsky, *The Conception of Buddhist Nirvāna*, p. 38.

appearance of a finished product of rational insight and careful observation. It is but rarely that he rests content with quoting authority, and when a vital point is at stake he plays the rationalist with such an exquisite thoroughness and skill that his scholastic reverence for the Vedas threatens to pale into a mere lip-homage to an authority which cannot be openly disobeyed. This rational foundation of the Vedānta thought has been rightly discovered by P. Deussen who, while noting that the Vedānta helps itself out of the difficulties arising from its condemnation of the secular canons of knowledge "by the shortcut of substituting a theological for the philosophical means of knowledge,"[5] sees at the same time that Śaṅkara "makes a far more extensive use" of philosophic reflection as an aid than might appear from his anti-rational expressions, and that its perfection in this respect "may itself speak for the fact that we have to do here with a monument of Indian antiquity not merely theological, but also in the highest degree philosophical."[6] That Śaṅkara's profound respect for the Vedas has not successfully silenced the voice of Reason is indirectly admitted even by Dr. Stcherbatsky who while complaining of his negative attitude to logic proceeds in the same context to emphasize Śaṅkara's accusation of the Mādhyamika on the ground that the latter disregards all logic. Śaṅkara, it is said, treats the Mādhyamika with great contempt for his denial of "the possibility of cognising the Absolute by logical methods."

It is true that he frequently anathematizes unfettered and unbiassed reasoning. Rational disquisitions, according to him, require the moderating influence of Revelation to conduct them to the Absolute Truth. The real foundation of his misology, however, does not seem to be an

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[5] *The System of the Vedānta*, p. 90.

[6] *Ibid.*, p. 96.

inherent distrust of Reason, though some of his expressions, as we have admitted above, lend countenance to an audacious outspoken scepticism. Paradoxical as it may appear, Śaṅkara's distrust of pure reason has its moorings in a profound love of reason. The self-fulfilment of reason is not to be found in immethodical and desultory argumentations based upon individual idiosyncrasies; reasoning, when pursued on no better ground than the satisfaction of a solitary impulse or the desire for intellectual victory, leads to no definite conclusion. The test of true reasoning, on the other hand, is the unity of result in which the process terminates; it is the universality and necessity of the conclusion which provides the surest criterion of good reasoning. As the Scripture stands this test of unity and universality, as it is in this sense objective reason writ large, all individual rational processes must be conducted under the guidance of Revelation.

That this is the real intention of Śaṅkara's denunciation of reasoned knowledge seems to be evident from a number of considerations. The apparent anomalies and conflicts of the scriptural texts, according to him, are not devoid of a unity of significance; nor do they really contradict tradition (*smṛti*) or reason (*nyāya*) when the latter are rightly conceived. Hence, a considerable space (*viz.*, Chapter II, Part 1) is devoted to the removal of apparent contradictions between Revelation on the one hand and *smṛti* and *nyāya* on the other. If reasoning had been altogether subversive of Revelation or *vice versa*, there could arise no question of their reconciliation; and in that case, Śaṅkara, like the Latin Fathers such as Tertullian and Arnobius, would unhesitatingly adopt the sceptical doctrine of *Credo quia absurdum*. But, far from avoiding all contact with reasoning and discussions, every objection to Revelation on the ground of reasoning and ordinary experience is carefully discussed in order to exhibit its

hollowness. All such objections are supposed to be due to errors of judgment or misinterpretations of experience; and consequently they are found to have no force when these errors and misinterpretations are avoided.[7] What is condemned, therefore, is, not any and every type of reasoned knowledge, but purposeless dry hair-splitting (*śuṣkatarka* or *kutarka*) which leads to no definite conclusion. That is, it is not Reason *as such*, but the misuse of the reasoning faculty, which misses the truth; but as it is extremely difficult to steer clear of the infinite sources of error in our reasoning processes, and as it is not always easy to detect the logical aberrations in the arguments of an accomplished dialectician, the agreement of our reasoned conclusions with the Scripture provides the safest criterion for us that we are not so far off the right track.

Śaṅkara's respect for independent reasoning is perhaps nowhere more pronounced than in the *tarkapāda* of his Commentary. None who is entirely sceptical of the efficiency and finality of reasoned knowledge would care for a reasoned refutation of the arguments offered in support of rival theories. And Śaṅkara has no doubt in his mind that all arguments that have ever been advanced for building up non-monistic theories of the universe are but pseudo-arguments and that their fallacies can be detected, not only by the disparity existing between their conclusions and Revelation, but also by a more carefully conducted reasoning *independent of Revelation*.[8] It is easy to guess that a consistent sceptic cannot pronounce an anathema on all reasoning processes while himself claiming finality for his reasoned refutation of the rival theories, especially

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[7] *Nairāsmadīye darśane kiñcidasāmañjasyamasti*—S.B. II. 1—9.

[8] *Iha tu vākyanirapekṣaḥ svatantrastadyuktipratiṣedhaḥ kriyate.*—II. 2. 1.

when this refutation is undertaken independently of Revelation. Śaṅkara himself, in acknowledging the need for a reasoned refutation of the non-monistic systems, admits the distinction between false exposition (*vyākhyānābhāsa*) and true exposition (*samyagvyākhyāna*), thus implying a similar distinction between pseudo-reasoning and true reasoning.

It is, however, surprising that while insisting on the unknowability of the Absolute in the light of the human faculties of knowledge, Śaṅkara has also the tendency to acquiesce in an unrestricted application of reasoning to all spheres of reality including the Absolute. This tendency is particularly prominent in his exposition of the *Bṛh. Upaniṣad*. The Yājñavalkyya-kāṇḍa is said to be pre-eminently argumentative in character (*tarkapradhāna*) as distinct from the Madhu-kāṇḍa, and the Absolute is supposed to be reasoned out (*vādena vicāritam*) on the ground that the knowledge of the Self which leads to immortality can also be attained through arguments.[9] Such passages are in evident conflict with those which breathe the agnostic tendency of Śaṅkara's epistemology. It may be suggested that even here Śaṅkara has in mind, not independent reasoning, but arguments under the control of Revelation (*śrutyanugṛhīta tarka*). But such a suggestion would hardly fit into the contexts in which the passages occur.

If, however, Śaṅkara's epistemology is to be worked out of the general spirit, as distinct from the *ipsissima verba*, of his contentions, it must be characterised, not as rationalism such as is represented by Leibnitz or Hegel, but as agnosticism of the type which is the result of Kant's *Critique of Pure Reason*. What, however, appears to

[9] *Tadeva tarkeṇāpyamṛtatvasādhanaṁ sasannyāsamātmajñānaṁ adhigamyate*. Cp. also *Com.* on *Gauḍapāda Kārikā* III. 1., where it is said that the Absolute can be known even through arguments (*śakyate tarkeṇāpi jñātuṁ*).

need emphasis is that Śaṅkara's repudiation of rationalism or panlogism does not militate against his respect for reason, and it would be perhaps no exaggeration to say that his implicit faith in Revelation would not allow any ultra-rational pronouncement to over-ride the results of carefully tested observations or of reflective judgments. While waxing eloquent on the unthinkability of the Absolute which is supposed to be too deep for human faculties of knowledge, he leaves at the same time a wide scope for independent thinking and observation.

That a strong under-current of free thought flowed beneath Śaṅkara's scholastic reverence for the Holy Writ is also evident from some of his momentous observations on the limits of the Scriptures. He agrees that even the holy texts cannot make us understand what is contradictory and, consequently, proceeds to remove the apparent contradictions with regard to the nature of the Absolute.[10] The Śāstra, it is said elsewhere, is not out for changing the nature of things, its real function is to make known the true nature of what is not known; fire will not be cool, nor will the sun cease to burn, even if the Scripture reiterates such examples a hundred times.[11] And the reason why such examples are ineffectual for knowledge is said to be the contrary testimony of other sources of knowledge. (*Pramāṇāntareṇānyathādhigatatvāt vastunaḥ.*) If this line of thought is developed to its logical consequences, Śaṅkara's position may be called agnosticism which accepts

[10] *Śabdenāpi na śakyate viruddho'rthaḥ pratyāyayitum*—S.B. II. 1. 27.

[11] *Na śāstraṁ padārthān anyathākartuṁ pravṛttaṁ kiṁ tarhi yathābhūtānāmajñātānāṁ jñāpane . . . nahyagniḥ śīta ādityo na tapatīti vā dṛṣṭāntaśatenāpi pratipādayituṁ śakyam*—*Com.* on the *Bṛhad. Up.* II. 1. Compare also *nahi vacanaṁ vastuto'nyathākaraṇe vyāpriyate kiṁ tarhi yathābhūtārthāradyotane*—*Com.* on *praśnopaniṣad*, VI. 2.

the validity of human knowledge within certain limits only, as distinct from scepticism that questions the general validity of knowledge. The Absolute, then, is unknowable except on the basis of the Scripture, not because our knowledge is inherently defective, but because the Absolute is supersensuous (*atīndriya*). Each source of knowledge has its own sphere of application; contradictions arise only when the canons of knowledge are misapplied beyond their respective fields. This aspect of Śaṅkara's theory of knowledge is emphasised by Sureśvara and Vācaspati. The different sources of knowledge, it is said, do not conflict with one another as they pertain to different objects; each is valid within its proper field; but when two conflicting judgments are made about the same object, one of them must be false.[12] It would be absurd, it is continued, to urge that the right canons of knowledge can contradict each other, because the testimony of a particular source of knowledge can neither be refuted nor corroborated by that of another, much as it is absurd to argue that this is not a sound on the ground that I see only a colour.[13]

Enough perhaps has been said to show that Śaṅkara, if he is taken literally, has as many as three distinct tendencies in his epistemology, which may be respectively called scepticism, rationalism and agnosticism. When, however, we refuse to run away with isolated passages in which these conflicting theories are supported, when, that is, his position is considered as a whole, it is predominantly an agnostic theory of knowledge which is defended by

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[12] *Na tu pramāṇaṁ sat pramāṇāntareṇa virudhyate—Naiṣkarmyasiddhi*, III. 96.

[13] *Nāyaṁ śabdaḥ kuto yasmāt rūpam paśyāmi cakṣuṣā, iti yadvat tathaivāyaṁ virodho'kṣajavākyayoḥ—Loc. cit.* III. 84. This is clearly indicated even by Śaṅkara when he says: *na ca pramāṇam pramāṇāntareṇa virudhyate, pramāṇāntaraviṣayameva hi pramāṇāntaraṁ jñāpayati—Com.* on *Bṛh. Up*. II. 1.

Śaṅkara. In this regard, the method of the Advaita school offers a strong contrast with that of Buddhistic monism. In the second period of Buddhistic philosophy, when monistic systems replaced the radical pluralism of the first period, the *dharmas* including the *skandhas*, *āyatanas* and *dhātus* were reduced to mere shadowy existences. And as these alone were supposed to constitute the phenomenal world of ordinary experience, it was condemned as a mere *saṁvṛti-satya*, as distinct from the non-relational Absolute revealed in mystic intuitions alone. But the nemesis of universal scepticism or unqualified relativism worked itself out when the Absolute Reality also reduced itself to the status of the dependent or relative reality. Buddhistic philosophy, however, assumed a saner attitude to reasoned knowledge at the hands of Diṅnāga and Dharmakīrti who replaced the universal scepticism of Nāgārjuna and Candrakīrti by a sort of modified rationalism.

The germ of scepticism, as we have seen above, was not altogether absent from Śaṅkara's position, though it did not develop into a full-fledged theory at his hands. But the dialectic method of the Buddhist thinkers provided an attractive weapon for the followers of Śaṅkara who lost no time or energy in applying it in the interest of absolute monism. Hence, as early as the beginning of the ninth century Maṇḍana Miśra sought to expose the self-contradictory nature of the concept of difference in his *Brahmasiddhi*, and the dialectic was subsequently applied to all the categories of thought by Śrīharṣa, Citsukha and other distinguished thinkers of the Advaita school. Thus, the inchoate scepticism of Śaṅkara developed into an unqualified misology at the hands of his followers; and the Advaita dialecticians, like Śrīharṣa and Ānandajñāna, instead of limiting the validity of human faculties of knowledge to the phenomenal world, paved the way to universal

scepticism by a negative criticism of every category of thought. A similar degeneration of the Hegelian criticism of categories is illustrated by Bradley's *Appearance and Reality*. A category, for Hegel, is no doubt self-discrepant, but this is due to its forced abstraction from the higher category in which the inconsistencies of the lower category are reconciled. For Bradley, on the other hand, every category of knowledge can give us only appearance, and in this regard, one category is as bad as another. It does not, therefore, appear to be altogether true that there is great "family likeness between the dialectical method of Hegel and Nāgārjuna's dialectics,"[14] if this is meant to deny the important difference between the immanent criticism of the categories which alone is recommended by Hegel and the purely negative criticism undertaken by the Buddhist and the Advaita dialecticians. The result of this negative criticism is that the Dharmakāya of Nāgārjuna, the Brahman of Srīharṣa and the Absolute of Bradley, far from being the crowning phase of man's search for absolute truth, are simply shot out of a pistol.

For Śaṅkara, on the other hand, thought or intellectual interpretation of experience, far from being a useless superfluity, represents an indispensable stage of discipline leading to the highest type of experience in which the Absolute Reality stands self-revealed. It is true that the Absolute, for him, transcends the powers of discursive thought, and, consequently, our faculties of knowledge are inherently incapable of giving us the highest truth; but inasmuch as the path to the highest experience lies across the region of discursive thought, a rigorous exercise of intellect must precede that experience. The Absolute, therefore, is not to be realised through mere scriptural texts, nor is the scrupulous exercise of reason a blasphem-

[14] Dr. T. Stcherbatsky, *Nirvāṇa*, p. 53.

ous deviation from the path of God.[15] Each step of the threefold discipline has its proper function which cannot be performed by another. Consequently, the expression of the Highest Reality in the relational form of discursive thought has the useful function of stimulating thought to go beyond itself. This aspect of Śaṅkara's epistemology requires more emphasis than it has so far received at the hands of his exponents and critics.

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[15] *Asau dṛṣṭo bhavati śravaṇamananānididhyāsanasādhanaiḥ . . . nānyathā śravaṇamātreṇa—Com.* on the *Bṛh. Up.* IV. 2. 5. Cp. *Aparokṣānubhūti:—Notpadyate vinā jñānaṁ vicāreṇānyasādhanaiḥ.*

SECTION IV

ECONOMICS

ECONOMICS OF INDUSTRIAL FATIGUE AND ACCIDENTS AND LABOUR WELFARE

(A study of " Some Economic Effects of Industrial Fatigue and Accidents on Labour Efficiency and Welfare ")

BY

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CONTENTS

AUTHOR'S NOTE

The isolated researches on Industrial Accidents and Fatigue by scientific workers in England and the United States and by a number of Italian physiologists, need to be co-ordinated in a systematic study, before they can be properly appreciated and utilised by industries and labour welfare workers. I, therefore, hope that this humble attempt at a brief and popular presentation of a highly technical subject touching alike the borderlands of Economics, Physiology and Psychology, will receive some encouragement from competent scholars, as well as the public.

I have not been able to give this a more coherent shape due to other pressing engagements. I have tried to make full acknowledgments as far as possible; and for any omissions, I request the indulgence of authors and publishers concerned. I hope to bring out in due course a more comprehensive treatise when I shall remove any shortcomings of the present Edition.

I am under deep obligation to my esteemed teachers, Professor C. D. Thompson and Mr. S. K. Rudra, M.A. (Cantab.), to the latter in a very marked degree, for their kindly guidance and helpful criticism throughout my Research Study. To Prof. Thompson, I am particularly indebted for his extensive final revision of the Manuscript and graphical illustrations.

Economics Department,
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March, 1933.

H. L. SRIVASTAVA.

I. INDUSTRIAL LIFE: A PRELIMINARY SURVEY

A modern industrial undertaking is a complex phenomenon, and presents problems as complicated as the human organism itself. There are three main factors in an industry—*the work, the worker and the environment.* These three cannot be considered in isolation, as they are very inextricably interrelated and naturally react on one another. Therefore no study of industrial relations or industrial "machinery"—if we may use the term to indicate the whole industrial process—can be fruitful if we do not have in mind this complex nature of the phenomena we are studying.

Three main factors in industry.

With the growth of modern industrial technique and a very wide awakening of working-class consciousness in all parts of the world, so many new factors, ideas, instincts and impulses are coming in conflict with one another in industrial life, that the immensity of apparently simple problems connected with industrial labour, must be a challenge to the dogmatism of any scientific student. The study of the human factor in industry is assuming greater importance every day. There are so many tendencies and instincts which are competing for a powerful play in industrial activity—the instinct of self-assertion and workmanship, the "aggressive impulse," and the "instinct of escape," inner conflict and repression--all of which materially influence the output and the efficiency of the worker. "Industrial relations," as Dr. Drever points out, "depend essentially on the interests, impulses,

Industrial Life a complex phenomenon.

sentiments and passions of human beings;"[1] and these in relation to a mechanical environment in the factory and the workshop "present a complexity which may in certain aspects be both mechanical and organic, but is also spiritual"[2]—spiritual in the sense that they touch the deepest springs of human thought and action.

Importance of Fatigue study in Labour Economics.

A thorough study of the problems of Labour Welfare or Organisation calls for information on a variety of subjects—Psychology, Physiology, Economics and various Social Sciences, and also something of Mechanics and Engineering. The problem of Industrial Fatigue is likewise one of the most elusive studies in Labour Economics, and requires to be studied as the resultant of so many psychic and environmental factors. We have emphasised the psychic influences just as much as the economic results accruing from their presence in the worker's organism. Though there is a vast and growing literature on the subject of Fatigue in industry, it must be observed that the essential nature of Fatigue and its exact quantitative measurement are still baffling investigation. We know of course much about the effects of fatigue in a general sense, but this does not help us in coming to any scientific conclusion about its complete eradication or evaluation of its economic consequences, except in a conjectural sense. We are putting this so very clearly at the beginning, as otherwise so many excellent experiments and observations of the Industrial Fatigue Research Board and other research institutes may lead the unwary reader to believe that it has been possible to *finally* analyse Fatigue and that modern science has enabled us to know it in all its

[1] J. Drever: Human Factor in industrial relations—Article in the Industrial Psychology: edited by H. Myres: Home University Series, p. 17.

[2] C. S. Myers: Industrial Psychology, *ibid.*, pp. 17—19.

elusive aspects. But with increased perseverance to seek out things in their innermost recesses, characteristic of modern Science, there is no reason why we should not hope to get a full knowledge of this phenomenon in due course.

The importance of this study is so widely recognised that it is unnecessary to discuss its possibilities in much detail. A correct and indisputable knowledge of the "Fatigue Factors" will affect labour legislation tremendously, almost radically. It will give workers a correct appreciation of the conditions under which they should be willing to work. It will also at the same time indicate to short-sighted employers that some of their very favourite schemes of hours and organisation in the interests of economy, may not be as paying as they imagine, and may in all probability be economically harmful. From the social point of view the importance of this knowledge cannot be over-estimated. It may lead to great changes in social standards and policies, in relation to labouring classes.

With the growth of modern social conscience, and partly due to preachings of a number of brilliant literary geniuses, like Ruskin and Carlyle, against the evils of modern industrialism, our attention has been focussed on the human aspect of industrial life, and all advanced industrial countries have tried to give a concrete form to this attitude in a comprehensive code of industrial and labour legislation to safeguard the health and welfare of the working classes. Great attention has for instance been recently paid to "accidents" and injuries arising "during and in the course of employment."

Industrial Accidents.

The problem of Industrial Accidents has recently aroused very great interest in western countries on account of the exceptionally heavy toll of life and severe injuries caused in some of the large industries every year. The causes leading to

accidents are as complex as those leading to Fatigue; and in a sense they require much greater attention to environment and safety of the mechanical equipment, which makes their study highly technical.

Accidents may be due to several causes one or more of which may be present at the same time. For instance some new writers like Vernon and others suggest that about 80 to 90 per cent of the accidents are due to what they call "carelessness" or "inattention." To us these terms are not expressive enough, and indicate to some extent paucity of precise knowledge and are intended to cover certain elusive and unexplained phenomena. For why should one be fully satisfied with an explanation like "carelessness and inattention" which are general terms covering a host of psychic states and changes in attitude, and not find out the causes of these in their turn? The Industrial Fatigue Research Board seem to realise this, when they have tried to fix the responsibility for a large proportion of the accidents to the special "proneness" and "susceptibility" of individual workers. For what passes as "apparent carelessness, seems on medical scrutiny the result of deep-seated causes of mental and psychic infirmity" (*Peri*).

The exact meaning of the term "accidents" has been the subject of deep controversy, and many legal decisions.

Definition of "Accidents."

As we are not here concerned with the legal aspects of the question, we are content with giving what appears to us an useful definition.

The expression 'Accident' is used in the popular and ordinary sense of the word, as denoting an unlooked-for mishap or untoward event (occurring in the course of employment) which is not expected or designed (Lord Macnaughten: in *Frenton Vs. Thurley & Co.*, 1903, A.C., 443, page 44). By a later case this definition was extended

by the House of Lords, and it was decided that the mishap or occurrence must be looked at from the workers' standpoint, and whatever its cause or origin, it will be treated as accidental unless caused by the workman himself." (*Trim Jt. Distt. School vs. Kelly*, 1914.) The definition has been held wide enough to include extreme case as heat-stroke, chill developing into inflammation of the kidneys, the rupture of an aneurism in such an advanced state that it might burst during sleep, and murder."[3] Therefore an accident does not exclude diseases like anthrax and mercurial or lead poisoning contracted due to definite association with a certain type of employment, and many occupational diseases are included in the Workmen's Compensation Laws in most countries. This would make the meaning of "Accidents" clear for all practicable purposes even from the legal point of view.

The frequency with which industrial accidents occur is on the whole rising in most industrial countries, and Some Statistics. they are numerous enough to constitute a "tremendous toll on economic production." In 1907, there were no less than 35,000 Fatal accidents in the United States; in 1913 and 1917 they diminished to 25,000 and 22,000, and serious accidents amounted to over 7,00,000. In New York State accidents have actually increased between 1922-23 and 1923-24 by over 26%, and the number of fatal accidents increased for the same period by 60%. In Great Britain the fatal accidents have of late averaged 1,200 in factories and 1,200 in coal-mines and quarries; and serious accidents causing temporary disability of a week or more amount to 1,20,000 in factories and workshops and 200,000 in coal-mines annually, and there are ten times as

[3] Tillyard: The Worker and the State, pp. 201—203.

many minor injuries.[4] These illustrations from two of the chief industrial countries clearly bring into relief the terrific pain, and huge economic damage to manual skill and capacity, and loss of time from sickness caused by accidents. In other countries the conditions are decidedly much worse.

We give a *TABLE* showing the number of recorded accidents in various countries, which obviously are not comparable as they are not made on an uniform basis. In few reports of accidents, which we have seen for various countries, an attempt has been made to calculate the "movement" of accidents in terms of the variations of their "frequency" and "severity;" and unless that is done, we cannot make any scientific generalisations. This neglect in almost every country shows that public and administrative conscience is not yet fully alive to the importance of this great problem. In Great Britain, the "prevention of industrial accidents" is said to be the most important problem before the Factory Department" says the Annual Report of the British Chief Inspector of Factories for 1922, yet figures on a "common base" are seldom available, and "only a few firms make an analysis of their accidents on a scientific basis."[5] As things are at present only a few employers have an idea of the accident problem even in their own works.[5]

Countries.	Industrial Population in millions 1922.	Accidents.			
		Year of Report.	Approximate Total Accidents.	Fatal.	Increase over last year or decrease.
Great Britain	13·0	Last few years' average.	320,000	2400	

[4] Downey: Workmen's Compensation and I. L. R.—Vol. 13/15, pp. 672-73.

[5] Safety Work in Great Britain in 1922, and I. L. R.—Vol. IX, p. 606.

Countries.	Industrial Population in millions 1922.	Accidents.			
		Year of Report.	Approximate Total Accidents.	Fatal.	Increase over last year.
Austria ...	...	1920-21	25,900	201	4000
Czecho-Slovakia	2·5	1923	36,975	271	3000
Saar Basin ...	...	...	03,822	37	Increasing
Sweden ...	...	1923	41,996	239	"
Switzerland ...	1·0	...	...	...	
United States...	...	average	...	25,000	
Factory Population in 1919 = 9,096,372		1907	2,000,000	35,000	Do.
		1913	"Seriovs" 700,000	25,000	
		1917	500,000	22,000	
Japan ...	5·0				
(Factory Population 1·3 million.)		1925	32,000	18_1	Do.
India ...	8·0	1925	12,645 Factories	284 only. "484"	Do.
India ...	From R. K. Das' "Production in India."	1925 Mines	...	233	33 more fatal accidents in 1925 over last year.

N.B.—These figures not being classified on a "common base" and derived from different sources are not properly comparable.

Accident Statistics in India.

In India of course we cannot expect much progress as accident records were made compulsory only from 1924; and though we find the Bombay Factory Report insisting on some "internal classification," it is still in its infancy.[6] A scientific detailed analysis of "frequency" and "severity" rates must be legally enforced, and an uniform basis of accident record must be adopted in all

[6] Bombay Factory Report, 1927, p. 16.

provinces of India as soon as possible. In this connection India suffers under a great disadvantage as compared with England as there is no Chief Inspector of Factories for the whole of British India to coordinate the records and supervision in various provinces on a more or less uniform basis.

On this technical question of "statistics of safety," it is worth while to quote the greatest American authority on compensation statistics, Dr. Downey. "Causes must be correlated with the the number and severity of injuries in order to indicate the relative importance of each hazard . . . Mere frequency of injury is of little value. The preponderating causes of deaths and permanent injuries are very different from most frequent causes of minor and temporary disabilities. To measure the total importance of any hazard therefore, it is necessary to convert injuries of several degrees of severity to some common denominator, such as Compensation cost, or weighted time loss. By this device the relative significance of the several causes of injury is plainly shown and comparison of hazards is made possible from industry to industry or from state to state."[7]

Precise method of Statistical Classification.

The importance of the study of industrial accidents is unquestionable from the social or from the economic point of view. It is the duty of Society to see that this sort of unauthorised murder should be prevented in the modern industries at all costs in the interests of civilisation and humanity, and the risks of severe injuries and fatal accidents must be minimised. Simply compensation laws do not do either for the worker's family or society. From the employers' point of view, the *real* economic loss is enormous, and any permanent reduction in accident rate must be to the advantage of the employers as well as the whole society.

The Social Standpoint.

[7] Downey: Workmen's Compensation, pp. 136-37.

In the United States, figures are not available on an uniform basis. But Dr. Downey calculates the total economic loss from fatal accidents in the United States to be at least a billion dollars. The loss from temporary disabilities is small compared to fatalities. "The victims of serious accidents are generally men in the prime of life, for it is precisely the young and the vigorous who predominantly engage in extra-hazardous employments." In the Pennsylvania Compensation Accident Experience, of 8550 fatal or serious injuries, 60 per cent of the workers were under 40 years, of which 50 per cent were between 21 and 40, and 6·5 per cent only of the total were over 60 years.[8]

Economic Loss.

According to Downey's calculations for the United States, " a fatality upon the average cuts off 20 years of productive labour and a permanent injury causes a continuing economic loss proportionate to the age of the worker and the degree of incapacity. Upon the average each death or permanent total disability is equivalent to two hundred and fifty temporary disabilities of four weeks' duration. Reckoned in the same manner, the loss of a hand is equal to 500 weeks of total disability, and blindness of one eye entails an ultimate loss of six years' " duration."

Downey's Economic Rating for Various Accidents.

Weighting the deaths and permanent disabilities on the basis of the International Scale of Severity Rating, the total annual time loss from these in the United States is equal to 40 million working weeks; and taking all industries together the effect is of cancelling one week's production every year. In the bituminous

Economic Loss from Accidents in the U.S.A.

[8] Pennsylvania Insurance for Workmen's Compensation: Statistical Analysis, 1916—20 and Downey, p. 2.

coalmining it cancels one-tenth, and in structural iron workings it has the effect of cancelling one-fifth of the normal working time.[9] The calculation has obviously disregarded the cost of hospital care of the injured. The accidents in the mines and quarries of Great Britain were also calculated to have the effect of a week's disablement every year.[10]

The figures of economic loss mostly in terms of compensation, prove the great importance of the study of the causal factors of Accidents. The purely human cost in suffering is enormous and unmeasurable: but we can have some idea of the economic cost caused by modern methods of production to society. It is now common to treat compensation cost for accidents as a normal cost of industry, for in a certain sense they are due to nobody's fault. The society is responsible for these injuries, and it is on a just principle that it is held liable to pay for them.

Statistics of Accidents in India.

In India where statistics are so unsatisfactory and no provincial or all-India tables of statistics classified on the above lines are available, we cannot form any exact idea of the gravity of the problem. But as the safety devices and workers' general intelligence and training are so very inferior to western countries, we can safely conjecture the economic effect to be much more than a week's time loss every year by reason of the various types of disablements.

An approximate Calculation of Economic loss from Accidents in India.

According to a rough calculation I made on Downey's rating, the economic loss from 517 fatal accidents in the coal-mines and factories in India works out to about $5\frac{1}{2}$ lacs working weeks of time loss ($517 \times 20 \times 52$ or 537,680) or equivalent to the effect of $5\frac{1}{2}$ lacs of

[9] Downey: Workmen's Compensation, pp. 2-3.

[10] International Labour Review: Survey of Mining Inspn. Rept. G. B., 1923.

week's disablement of all the workers every year. The total loss in wages from the fatal accidents alone will be roughly 41 lacs of Rupees, if we assume the average weekly wages to be those of the Bombay Cotton Mill workers, that is, Rs. 7-9-0 a week or Rs. 1-4-2 per day.[11]

If we suppose that the economic loss from the Minor and Permanent Disability Accidents is equal to four times the estimated Time Loss value of the Fatal Accidents, which may not be a very high estimate for a country like India where factories alone have 126,645 recorded Accidents of more than three days' disability, the approximate *total Time Loss annually works out to about 22 lacs of working weeks' disablement*, and *the loss in Wages* pro rata is approximately equivalent to *164 lacs of Rupees*, for both the factories and mines. Adding the two series of figures, we find the total economic cost of all the accidents in India is equivalent approximately to about 27½ lacs of Working Weeks' Time Loss, and about 205 lacs of Rupees worth of Wages every year. It may be objected that both the American expectation of Life and the Bombay Mill Wages appear rather exorbitant for application to the whole of British India; but we must remember that this is only a rough estimate, and we have to compensate for the serious degree of under-reporting of accidents and minor injuries common in most Indian factories and also for the sweated wages paid in some industries in India.

Accidents and the League of Nations.

The importance of the study of industrial accidents has now been amply established from the facts which we have discussed. The League of Nations have long recognised its international importance, and many exhaustive studies and reports have been made by the

[11] Report of an Enquiry into Wages and Hours, Bombay Cotton Mills, 1923.

International Labour Office and its successive international conferences. The League have adopted several Conventions and recommendations on its various aspects with a view to prevent Accidents and occupational hazards. Its importance to labour welfare is quite obvious, and now the safety and health of the workers in every country have to be looked upon from an international and all-world point of view. This international outlook is a guarantee that the physiological demands of the workers' body and mind will receive an impartial and just consideration.

Few accidents are entirely unpreventable.

"Both the employer and employee" says Stephenson, "are so intent on production that accidents in industry are liable to be regarded simply as accidents, that is as unforeseen occurrences, and therefore unpreventable."[12] As our study shows there can be no greater misunderstanding, for as a matter of fact, there are very few accidents, even those which are due to the so-called "carelessness and inattention" of the workers which cannot be prevented or at least substantially mitigated by proper care for the psycho-physical requirements of the workers, and their environment in and outside the factory.

[12] A. Stephenson: Industrial Accidents—Article in Industrial Psychology: edited by Myers (Home University Series), p. 122.

II. DISTRIBUTION OF INDUSTRIAL ACCIDENTS BY OCCUPATION

Before discussing the causes of accidents let us examine their relative frequency in various occupations.

Certain industries are responsible for a relatively greater number of injuries than others, on account of varying degrees of risk involved in their operations. There are a large number of industries using chemicals like chlorine, hydrochloric acid, sulphur dioxide and sulphuric acid, nitrous gases, acetyn, benzene, tar, naphtha etc., which have poisoning effects in case of inhalation of their fumes and gases and carry varying degrees of hazard during machine operations.[1]

Hazard in Metal and Mining industries.

"Metal and mining are the most hazardous occupations while railroading, quarrying, and lumbering appear among those which exact heavy tolls in suffering and life." These industries according to the estimates of Dr. Hoffman are two or three times as dangerous as the average for all occupations in which male workers are employed.[2]

Statistics of Accident Distribution.

"Metal-mining" has a fatality rate of 4 per mille and "Coal mining" 3·5 per mille.[3] "General manufacturing" has only 0·25 per 1000, Navigation 3 per 1000, Railroads 2·40 per thousand, Electricians (light and power) have an average of 2·5 per mille; Quarrying has 1·70, lumber industry 1·5, soldiers in U.S.A.

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[1] International Labour Review: June and September 1926: "Industrial Diseases 1920—22."

[2] Watkins, G. S.: Labour Problems, p. 191.

[3] *Ibid.*, p. 192. Hoffman's table of fatal industrial accidents in the U. S. A. 1913 by Industry Groups.

Army had 1·49 per 1000, Building industry 1·25 and "Agricultural pursuits" had 0·35 per 1000 while general "Manufacturing" industries had an average of ·25 fatal accidents per 1000 in the U.S.A. in 1913.[4]

It is not possible to give such distribution ratios in Indian industries for most of the factory reports do not give any such classification.

Accident Distribution in the U.P.

The Annual Factory Report for the U.P., gives such a distribution by occupations for 1927; the following figures are quoted from the same :—

Classes of factories.[5]	Total and fatal accidents.	
	Total.	Fatal.
1. "Government factories"—ordnance, printing, Railway workshops etc., (19000 operatives.)	309	2
2. "Textiles"—cottons and woollens (28000).	80	2
3. "Engineering" including electric generating stations and Railway workshops (12000).	762	3
4. "Food, drink and tobacco." Rice, flour mills etc. (9000).	31	5
5. "Chemicals and dyes, etc." (Matches and bleaching and oil) (300.)	13	1
6. Paper and printing (3 serious)	7	0
7. "Wood, Stones & Glass"	3	0
8. "Skins & Hides" (2800)	12	0
9. "Gins & Presses" (cotton) (10000) ...	8	1
10. "Miscellaneous" (88000)	1	0
Total	1226	14

[4] *Ibid.*, Hoffman's table. (Adaptation.)

[5] Total number of operatives in U. P. Industries. *Ibid.*, 1927, p. 3 in brackets (in round numbers).

Thus we find[6] in the U.P. that Textiles, Government Factories including ordnances and workshops and engineering have largest number of total accidents monopolising about 95 per cent of the total accidents and 50 per cent of the fatal accidents. The largest number of fatal accidents appear in the "Food" industries in rice, sugar mills, etc., and this seems due to the large number of employees rather than the hazardous character of the industry.

We have figures for only a few other provinces on this basis and we do not know the relative incidence of accidents in the most hazardous industries, for example, the Iron and Steel and Coal industries in India.

Coal-Mining Accidents.

According to Dr. Downey, "*Coal-mining* leads all other employments in the annual number of fatal and permanent injuries and in the aggregate economic loss occasioned by work accidents. Nearly half of this total accident cost is attributable to falls of roof and coal, one-fourth to mine cars and motors, one-tenth to explosives and hoisting apparatus."[7]

In *manufacturing industries* as a whole mechanical equipment accounts for 60 per cent of total accident cost, according to the Pennsylvania Insurance Experience. It would be well if similar figures for India were also made available in the Factory Reports.[8]

INDUSTRIAL ACCIDENTS IN INDIA

Behar & Orissa—

The province of Behar and Orissa requires special attention in any statistical study of accidents in Indian

[6] Annual Factory Report, U. P. for 1927: W. G. Mackay, p. 10.

[7] Downey: *Ibid.*

[8] Downey: *Ibid.*

factories, for the greatest factory in India employing about 25,000 to 30,000 workers—the Tata Steel Works—one of the largest in the world—is situated in this province. The frequency of industrial accidents is largest in steel works and coal-mines. But coal-mines are not included in the factory reports and are treated separately in the Report of the Chief Inspector of Coal-mines, to which we must return later.

A study of industrial accident statistics in Behar and Orissa shows that the number of "Total Accidents" and "Mean" Accidents per 100 persons employed have been steadily rising between 1916 and 1918.

While the total accidents have maintained progressive increase between 1918 and 1922 along with the numbers employed, the "mean" of Accidents per 100 persons employed has shown a steady decline in these years except in 1921 when the average was 2·51 against 1·66 in the previous year. In 1922 there was noted a decrease in all types of accidents, while in 1923 the decrease was marked specially in more serious types.[9]

This welcome decrease in the figures for accidents does not necessarily indicate a real decrease in the risks and dangers in industrial undertakings of the province, for it may show that the reductions are to some extent due to the experience gained by the old employees in the Tata plants which fully came into operation after 1918. Again the increase in the number of total accidents does not necessarily imply a real increase in Accidents as the improved reporting which was gradually adopted after the passing of the Indian Workmen's Compensation Act (which made the reporting of Accidents compulsory) must account for a great deal of the increase.[9]

But this factor is common to all the provinces more or

[9] Behar and Orissa Factory Report, 1923.

less, and so there is not much difficulty in *roughly* comparing the factory accidents in various provinces, though *absence of a common basis* of classification of accidents must prove a source of considerable error. The special conditions obtaining in Behar and Orissa and particularly at the Tata Iron & Steel Company are clearly brought into relief by the Chief Inspector of Factories for the province.

Special Features of Accidents at Tata Works.

"The conditions which produce accidents in the steel works are not paralleled by *any other* factory in the province, nor possibly in India. A conglomeration of many smaller factories to aggregate the same number of employees would not make an establishment resembling this in the nature of its dangers. The dangers in the normal small factory are of kinds that can be counteracted one by one by simple and inexpensive precautions (e.g., unfenced machine). But the characteristic danger in these works is of another kind much more vague and much more difficult to deal with. It is the danger inherent in the combination of conditions which I would place in the following order of importance :—

(*a*) The enormously high ratio of ignorant labourers to the small handful of skilled and educated officials.

(*b*) The fact that in addition to the mere extent of the establishments its plant units are mostly on a great scale of size and power.

(*c*) The circumstance that in spite of the size of the works and of the tracts of open country around them, the plant is relatively congested."[10]

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[10] Behar and Orissa Factory Report for 1923 (by Mr. Brady).

According to Mr. Brady, the conditions (*b*) and (*c*) which are of a physical nature, inherently dangerous as they are, would not produce in a steel works in Europe and America a remarkable accident rate. It is the first condition (*a*) and " the ignorance, the obstinacy, the instability and secretiveness " of the Indian labourer which brings in the two latter conditions. " *The secretiveness* of a partially trained coolie makes it difficult to find out of what exactly he is ignorant and to enlighten him—his *instability* discourages his immediate superiors from taking much trouble over him, for when he has been taught the conditions governing some particular place or job it is doubtful whether he will repay his instructor by remaining at it, and in his *obstinacy* he adheres to his rustic customs in spite of warnings that they endanger his life amongst heavy industrial plant."

Some statistics for accidents in the Tata Works.

A careful and detailed study of the average Accident Frequency at the Tata Iron & Steel Works, Jamshedpur, reveals very high and progressively increasing incidence of injuries incurred by the workers at this plant which is the largest industrial undertaking in India, employing a daily average of 25,000 to 30,000 workers in its various departments. Accident Frequency has been rising per 1,000 workers between 1922 and 1926 at an increasing rate from 2·08 in 1922 to 4·94 in 1926. In 1927 the rate remained constant with the preceding year. In 1928 there was a sudden rise from 4·81 to 5·64; and in 1929, the rate further rose to 6·90 accidents per mille of the workers employed; but in these two years there are certain extenuating circumstances due to abnormal Labour and employment conditions due to the Workers' prolonged Strike. The year 1930 however registers a slight decrease in accident frequency, 6·34 per mille, which is a salutary sign of considerable improvement

and settled conditions.[11] It must be observed that the tendency to increase in the average of injuries per worker has been very marked and progressive on the whole, though there is a silver lining in the clouds in the last statistical year.

The crude total accident rate has also been rising in a very marked degree, and for 1930 the reported cases of all types of injuries in the total plant amount to 28,775; of those involving absence of less than a day 27,181; and those involving lost time of 48 hours or over were 1,518, against a daily average employment of 18,496 operatives. We give a table with some more details for years 1925 to 1930 :—

	1925	1926	1927	1928	1929	1930
FATAL ACCIDENTS:						
Total Plant	16	33	28	24	10	20
Grand Total including contractors and town employees.	19	35	28	24	15	27
SERIOUS ACCIDENTS: Total Plant.	206	275	251	300	360	176

The number of severe accidents also indicates a steep rise progressively every year during this period. We regret very much that the Tata Iron & Steel Co. do not have properly corrected and classified Statistics on the lines for instance of the records of the United States' Steel Industries who prepare frequency and severity rates on the basis of per 1,000,000 hours of exposure. According to labour statisticians, this is the best method of classification. The classification of the accidents by Causes is also not available for the entire works according to present official classifications. The ordinary number and frequency classification as prescribed by the Indian Factories

[11] Figures supplied by the Tata Iron & Steel Co.'s courtesy.

Act does not yield any useful social data for ameliorative purposes. For this reason it is impossible to make any accurate comparisons of the Tata Steel Works accidents with similar Steel Works in western countries.

The data prescribed by the Indian Factories Act, do not give very expressive information on the salient causes of accidents, and their relative severity. We hope that the Government will make suitable amendments in the new Indian Factories Act, and try to approximate to the recommendations of the International Labour Office of the League and the Committees of the Labour Statisticians appointed by the I.L.O. The Tata Company however in view of their position as the leading industrial firm of the nation, and also in view of the comparative gravity and seriousness of the Accident Frequency in their Works should adopt more scientific tabulation and classification of the Accidents and injuries. They should not be content with merely complying with the Government demands in this respect.

In view of the difficulties in getting comparable Statistics, it seems rather premature and inadvisable to analyse the figures of the Tata Accidents too critically. There is no doubt however that compared with other industries of the Province, the toll of life and injuries and economic cost due to compensation is comparatively much heavy in the Tata plants. That itself does not call for any severe comment for the Iron and Steel industry is one of the most hazardous industries in all countries, and everywhere the number of injuries, and their qualitative severity is much more in the Steel industry than in any other.

The amount of pain and suffering caused in the steel and other hazardous industries must indeed be very great, and it is the duty of society to try to reduce them as much as possible in the interests of civilisation. The economic cost of injuries, in the case of compensable

injuries to the Tata Steel Co. comes on average to about Rs. 45,000/- annually, which is indeed a small figure for the Works of such a vast size. But when the amount of the experience lost due to the loss of an old worker, and the increasing cost of training and lesser efficiency of new recruits are considered, and the dislocation caused in the smooth working of the firm due to interruptions of injured absentees are all taken into account, the actual cost of accidents and injuries of all types (in this case about 29,000 reported injuries), must indeed work out at a high figure. As every sound industrialist must realise this is not an imaginative essay in estimating the cost of injuries. This conclusion is patent to any person who shall care to study the facts. But probably the enormous size of the plant, the dangerous nature of operations in the Steel Works, and illiteracy and instability of the labour force, and the comparative inexperience of the average worker will make a very much radical reduction in accident incidence of the Tata Works impossible. We have already referred to Mr. Brady's view about this aspect of the Tata plants, which bring into relief the various difficulties in mitigating the accident frequency here.

It seems however *prima facie* quite possible from the experience of other countries to bring a very substantial reduction in accident hazard, by taking suitable and preventive measures after fully investigating the causal factors. It is quite a wrong view from the point of view of the welfare of the industry to think that one should dispense with all preventive measures, and only provide a contingency fund equal to the cost of compensation roughly payable every year. It is a matter more of a firm's reputation for caring for its employees and social standards, which the Government and Society as well as the industrialists should watch very jealously. The experience of other factories and steel plants in Europe and

America suggests strongly that any reasonable expenditure and measures of a preventive character likely to reduce the hazard and increase the comfort of the workers must also increase the voluntary co-operation and loyalty of the workers. One big industrialist at a British Safety Conference stated it emphatically that he considers it a wrong policy to entrust the duty of looking to the accidents and injuries to the Insurance institution with whom his firm were insured. He wanted to attend to the injuries where possible himself through his own doctors. This in his opinion was not only more human but also quite paying, as he could in this way gain the personal confidence and respect and loyalty of his labour force whose contentment would result in a larger output, and for this he was prepared to make any investment. When we refer to such things we never imply that the attitude of the Tata Company has not been satisfactory towards their workers. In fact they are probably the best employers in India, who pay quite good wages and look to their labourers' welfare, in so many admirable ways. We are only referring to a certain attitude which big industrialists are tempted to acquire at times, in such matters, because they fail to take a long view of things.

The author had ample opportunities to study labour conditions at the Tata Steel Works, and to get the free opinions of the workers there, and also of studying the various welfare measures and labour conditions in other factories. The Tata workers are well looked after at least in the time of Mr. Keenan, the present General Manager. The Company pays full wages to the workers during their absence from the first day of the accident, though the Indian Workmen's Compensation Act makes it payable after two days have elapsed when the accident requires further absence due to incapacity of the worker. This indeed means extra cost, and shows the attitude of the

employers in approaching such questions. The workers rarely have occasion to resort to law courts for settlement of the compensation. Generally the compensations are paid promptly on a liberal basis.

Some suggestions for the Tata Steel Works.

The Tata Works have got a Safety Committee consisting of the heads of the departments who investigate the causes of accidents and decide the compensation payable. For such a vast plant one should expect an independent Safety and Accidents Department with full-time expert staff. An Industrial Psychology Department is also indispensable for such a vast Steel Works, as much smaller firms in Europe and the United States have got the services of a trained staff of industrial psychologists and labour investigators who make it their business to study scientifically the conditions under which the work is carried on, and make suggestions likely to prove useful in reducing Accidents and Fatigue and increasing the output, while at the same time increasing the comfort of the workers. Any such steps taken on the advice of such Industrial Psychologists and Research Workers have in almost all cases proved economically feasible, though sometimes the results have not been decidedly encouraging for the first two or three months of experimentation. In that case it is nothing more than a dollars and cents proposition.

Both the United States and the British Governments have got Labour Statistics Bureaux and the latter have had expert Committees and the Medical Research Council and the Industrial Fatigue Research Board, who have been engaged in studying such problems on behalf of the Government. It is unfortunate that the Government of India have never moved an inch so far in making any such specialised studies on expert lines of the Fatigue Factors or accident incidence or other labour problems of national

importance. The newly started Bureau of Industrial Research and Intelligence of the Government of India does not have a single specialist in industrial Economics or labour problems or industrial Psychology; and its scope and programme are altogether misconceived. In the case of a firm of the size of the Tata Works, and in view of its national importance as the premier industry of the country, the services of some industrial psychologist and labour economist appear almost indispensable, in the interests of the firm itself. Such a Research worker in industrial psychology must have studied the work of the Industrial Fatigue Research Board, and must have knowledge of labour and industrial conditions in other factories and mines as well as some Steel Works, and must have a thorough theoretical grounding in Industrial Economics and labour problems. We are not aware if the Tata Company have already made some beginning in this important matter. We think the study of psychological aspects of industrial life and work in the Departments like the Blast furnaces, Open-hearth and Duplex plant, the Tinplate and Sheet-Mills and the Merchant Mills, will yield most useful results, for there is a *prima facie* case for believing that certain important processes in these departments appear to be of a fatiguing nature, and a scientific study of the possibilities of introducing suitable rest-pauses must yield very useful results. If rest-pauses are scientifically determined and introduced after expert study of all the factors involved, the output is sure to increase after some time, and the comfort of the workers will also be enhanced at the time. The experience gained at the Munitions Factories and controlled Government factories during the Great War in Great Britain and other countries suggests that properly regulated rest-pauses specially in repetitive processes resulted in substantial increase in the output. It will be, however, sheer vanity

on the part of the heads of the departments of a big enterprise like the Tata's to believe that in spite of very busy distracted pre-occupations in the factory, they can make a competent and satisfactory study of the conditions of labour welfare, rest-pauses, accident or "Fatigue Factors" which requires special knowledge of Industrial Economics, Labour Problems and Industrial Psychology. They are eminently unsuited to make a proper study of such questions with necessary scientific detachment and precision; and all these will require a highly specialised type of knowledge. The knowledge and co-operation of these departmental heads and industrial experts will of course be indispensable to these industrial psychologists who should have direct dealings with the General Manager or the Chief of the Factory. As is quite patent from the experience of big industries in the West the expert Research Staff must certainly prove a profitable investment to the Company in due course,—and by making suitable practical suggestions about hours and rest-pauses and workers' comfort after scientific study increase the relative output and improve the relations between the employers and workers.

The Tata Steel Works are fortunate in having on their staff a sympathetic Labour Welfare Officer coming of a respectable Indian family, who is liked by the workers, but he appears to be understaffed. One solitary welfare worker can hardly suffice to deal satisfactorily with labour welfare questions in such a vast undertaking. The services of an industrial psychologist with some Labour Welfare experts must add very appreciably to the firm's capacity for looking to the welfare of the workers. We hope an eminent industrial expert and sympathetic Head of the firm as Mr. Keenan, at present the General Manager of the Tatas, who is ever solicitous to improve labour conditions, will do his best to consider these suggestions in the best

interests of the Company and the Indian workers under his charge.*

The researches of Dr. C. S. Myers and his investigators at National Institute of Industrial Psychology in Great Britain, the Munition Workers' Committees and the Industrial Fatigue Research Board under the British Government as well as the experts in Industrial Psychology, in many important firms in various countries, point only to one conclusion that no big industrial undertaking with a progressive and intelligent programme can afford to dispense with the services of such Research workers in its best interests. Then it is only large establishments who can afford to make such experiments; and examples of progressive measures adopted by them as a result of such experiments should prove a beacon light to other smaller industries and lead to the increase of the industrial prosperity of the nation and the betterment of the labouring classes.

These hurried suggestions are made regarding the possibilities in the Tata Works tentatively at the time of going to press, to fill a very important hiatus in this dissertation, and we propose to prepare a fuller monograph on the subject at a later date.

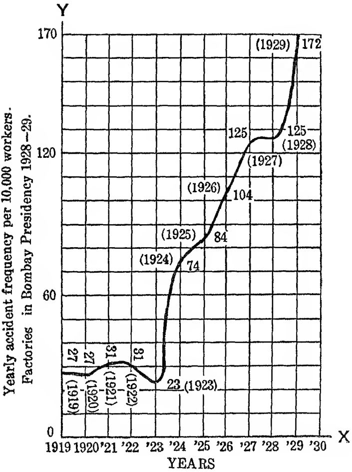
Accidents in Bombay Presidency.

Accidents in Bombay industries progressively increasing.

A study of the Curve for Accidents occurring in the Factories of the Bombay Presidency shows that the average Accident Frequency has been rising progressively at a very fast and alarming rate during the last ten years (*vide* Graph). The figure for the year 1929 showing the accident

* *N.B.*—These points are based on the writer's visit to the Tata Steel Works in 1931 for his research study; and also earlier.—*Author.*

hazard is about six and half times as much as the accident frequency per worker in the year 1919.



Graph showing yearly variations in Accident frequency per 10,000 workers in Bombay Presidency.
(Years 1919 to 1929).

BOMBAY FACTORY REPORT, 1928 & 1929

Accidents in Factories

	Fatal.	Total.	A s per 100 operative employed.
1919	26	1021	0·27
1920	33	909	·27
1921	34	1084	·31
1922	42		·31
1923	23		·23
1924	82		·74
1925	50		·84
1926	49		1·04
1927	59		1·25
1928	39		1·25
1929	51		1·72

Probable Causes.

This may be due to the constant influx of new workers in Bombay (and to some extent in other Mill towns), with probably the highest record of labour turnover of all the industrial towns in the world, owing to greatest possible instability of the labour force, partly due to its most insanitary and dirtiest housing conditions, and to the introduction of new machinery without proper accommodation which should not be allowed by the Factory Department. The effect of long hours and absence of proper rest-pauses may also be to some extent reflected in these high figures of accident exposure.

"Belt" Accidents.

Compared with the classification of 1928, there appears to have been a fall in accidents due to belts, which generally occur in the apparently simple process of replacing a belt. One man was killed in replacing a very slow belt. A belt fastener caught a bracelet he was wearing and he was taken over the shafting.[13]

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[13] Factory Report: Bombay: 1929.

Fire-proof garments and prophylactic injections.

Fire-proof garments were supplied in a match factory to the workers. Success in ammunitions factories at Kirkee in the reduction of accidents was due to special precautions taken by the management. No fatality due to tetanus occurred due to accidents in the carding engines in the Bombay mills which shows the beneficial effect of departmental action in previous years. Prophylactic injections at the hospitals for accidents are often given at the hospitals; and doctors often inject immediately after the accidents at the mills.[14]

This hurried review of the conditions of the accident frequency in Bombay suggests the importance of most vigorous efforts by the factory inspectorate to minimise the accident hazard, as far as possible.

[14] *Ibid.*

III. CAUSES OF INDUSTRIAL ACCIDENTS

The tendencies of large-scale production are to a great extent responsible for the increasing frequency of industrial accidents. Every new invention and process must be speedily adopted to compete with rival industries and workers have often to adapt themselves suddenly to new inventions, methods and even plants. "On account of the mechanical rut to which a machine must reduce its ordinary attendant, adaptation is generally not an easy thing and making allowance for technical training we must be prepared for maladjustment when dealing with large numbers of employees especially in India where workers do not have the requisite technical training in most cases and also lack the benefits of any primary education."[1]

Difficulty of workers' adjustment to factory environment.

Apart from inventions and new processes, "human nature as constituted cannot fully adapt itself to a mechanical standard."[2] Safely to perform their work without injury the workers must think and act exactly in terms of "mechanical exigencies" and should be as insensible to fatigue! "Human nature inherited from uncounted generations that knew not the machine does not possess these attributes in anything like the requisite degree" as Downey rightly points out, and specially must this be true in the case of the Indian villager who is called to a factory with all its modern intricacies, and complicated arrangements.

Inherent hazards of the machine economy.

[1] Downey: Workmen's Compensation.

[2] Downey: *Ibid.*

"The common man is neither an automaton nor an animated slide rule. His movements fall into a natural rhythm, indeed, but his beat is both less rapid and more irregular than the motions of machines with the consequence that he fails to remove his hand before the die descends and allows himself to be struck by a travelling crane. It requires an appreciable time for the red light or the warning gong to penetrate his consciousness and his response is apt to be tardy or in the wrong direction."[3]

Human organism not adaptable to mechanical exigencies.

Where hours are not exactly corresponding to psychological and nervous demands of the worker, fatigue overcomes him, and his attention flags "lengthening his reaction time and diminishing his muscular accuracy" thus enhancing his liability to accidents. Human organism is not perfectly adjustable to mechanical environment and no amount of training and safety measures and health improvement can effect the requisite adjustment "because the mechanisation of industry proceeds faster than the processes of habituation."[4]

Some causes of maladjustment.

Accidents therefore cannot be wholly avoided. The difficulty is increased when the ever-widening extensions of machine methods bring in a constant influx of men, women and lads from the villages from entirely opposite environments. Because of this, certain risk and injury are part of the cost of the maintenance of all mechanical industries and the probability of accidents can be forecasted in any group of industries. "The machine technology" uses stupendous forces like steam, electricity and chemical agents which multiply human power under proper control

Accidents cannot be wholly avoided.

[3] *Ibid.*, p. 7.

[4] *Ibid.*, and Thomas Oliver: Occupations.

and cause havoc where such control is relaxed. The worker's attention and energy must closely conform to the movement of the vast array of machinery which is propelled by these titanic power agents. All the movements of the machine and their purpose are hardly comprehensible to the ordinary worker, and on his slightest mistake may depend the lives of many others far removed from his operations.[5] Close interdependence of innumerable processes and apparatus is the chief cause of unavoidable accidents. "The hidden defect of a minor part or the momentary lapse of memory imperils the lives of hundreds. A lower man misinterprets an order and a train loaded with human freight dashes to destruction."[6] Every accident is ultimately traceable to some act of omission or commission, but often these are humanly speaking inevitable. Broadly considered injuries which arise are "nobody's fault in a personal sense." Workmen do not intend suicide neither do employers desire the destruction or amputation of the limbs of the labour force.[6]

Inherent risk of industry.

"All intensive studies of mass statistics show that work injuries in the main are attributable to inherent hazards of industry."[7] Most of the injuries arise from hazards characteristic of each occupation. In the most dangerous industry—*the Iron and Steel*—six characteristic causes account for 78 per cent of total accidents—travelling cranes 17 per cent, working machines 22 per cent and locomotive 12 per cent these three alone accounting for 51 per cent of the total. In bituminous coal mines one-half of the accidents are due to falls of roofs and coal. "Each industrial employment," says Dr. Downey, "comes to have

[5] Veblen: Theory of Business Enterprise.

[6] Downey: *Ibid.*, p. 7.

[7] Downey: *Ibid.*

a predictable total hazard," and each consumable commodity may be said to have " a definite cost in human suffering."[8] The specifically " human cost " of these cannot be shared or transferred, but the economic cost of the injuries must be included in the costs of industry and borne by the society of consumers, in the long run.[9]

Causes of Industrial Accidents:—

Classification.

Industrial accidents may be divided into " Preventable," " Inevitable " and " Unavoidable."[10] We have discussed in the last section the reasons for " Inevitable " accidents which are due to the " inherent hazards " of industry. They are due to the shortcomings of human nature, as measured by the standards of a mechanician. Then there is another class " Unavoidable " accidents which are beyond human control—such as falls caused by earthquakes or disturbed and tilted strata in a mine due to uncontrollable causes of a geological character, accidents caused by lightning, heat-waves or meteoric bursts. There is no human remedy for these and our study does not take account of these accidents.[11]

Inevitable and avoidable accidents.

Preventable Accidents.

We are primarily interested in the causes of accidents which are " *preventable* " and can be brought under control by science or man. The Preventable Accidents are an unnecessary drain on industrial finance and of late great attention is being paid to the study of their causes. On account of the new " efficiency movement " it is " gradually forging its way to the foreground " and accident prevention is

[8] *Ibid.*

[9] Brisco: Economics of Efficiency.

[10] *Ibid.*

N.B.—Dr. Brisco does not distinguish between " inevitable " and inavoidable." I thought that this distinction, however crude, was necessary.—*Author.*

[11] Brisco: *Ibid.*

being considered "an important duty of every business-man."

According to German statistics of Accidents, which Brisco considers quite reliable, 42·05 per cent of all accidents were due to "Unavoidable" risks of industry and 57·95 per cent to the negligence of employers and employees. According to one statistician at least 50 per cent of all accidents in the factories of America are preventable (Brisco).[12]

Preventable Accidents divide themselves into:—

Causes of Preventable Accidents.

1. Accidents due to subjective or psychical changes induced by particular tasks—like fatigue and nervous exhaustion, lack of co-ordination between speed of machinery and muscular movement, flagging of attention and dizziness; intoxication from drinks or drugs.

2. "*Non-machinery Accidents*" from external causes not connected with the use of machinery. Defective factory construction, bad lighting, temperature or ventilation, disorder in factories, overcrowding of materials, slippery floors, absence of fire precautions.

3. Accidents mainly due *to carelessness of* the employees—ignorance of danger or lack of training (for which employer is partly responsible on account of bad choice of his men), not using the safeguards provided, loose clothing, general overconfidence of employees.

4. "*Machinery Accidents*" or those attributable to inadequate safeguards and safety devices.

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[12] *Ibid.*, p. 253.

5. Accidents or injuries due to controllable and preventable "*occupational diseases.*"[13]

This rough *classification also indicates the reasons* for *each class of accidents.* It would be better to take each of these causes for brief discussion, and study the various methods suggested to prevent their operation.

"*Non-Machinery Accidents.*"—

There are a large number of accidents which are not attributable to the use of machinery but to the external conditions and environment provided for its operation.

Factory construction and design.

Factory Construction and design is not always suited to the needs of a modern plant and changes in the plant and use of new inventions often require drastic remodelling of old structures which is often neglected. The progressive needs of the workers and the extension of welfare activity introduce other complications. Says Miss Proud, "Adaptations are made in older works, and although it is more difficult to remodel an old inconvenient factory than to build a convenient one, there are not lacking examples of old factories which have been adequately adapted to the progressive needs of the workers. Movement from a city to a suburb or to the country is often associated with the building of a factory."[14] "It must not be supposed," she significantly remarks, "that a factory can be so built that it will be convenient for ever. Adaptations will be necessary with every development." It is "the first duty of a welfare department" and of a factory Inspector to keep a watchful eye so that the factory "may always be most convenient and comfortable" and over-crowding of

[13] Watkins: Introduction to Labour Problems.

N.B.—The writer has derived much help from *Brisco*: "Economics of efficiency" to which he makes full acknowledgment.

[14] Proud: Welfare Work, p. 257.

machinery and materials may be avoided—all of which would indirectly decrease the number of injuries.[15]

In India where rapid changes in machinery are required with increasing size of the plant such defects are common and often lead to large number of accidents. We find in the Bombay Factory Report 1923, that of a total of 82 fatal injuries, 30 deaths were caused by "*Collapses*." At an enquiry held into this structural collapse at the Ahmedabad Mill, it was found that "the expansions in the mill some years ago placed an overload on the original end wall which was converted into a party wall while last iron columns were overloaded" and "the effect of the vibration of a shaft penetrating an arch was the original cause of mishap."[16] At a second mill "an additional storey had been recently added . . . . and the walls of the extension were built of extremely poor concrete and cracks had developed under the girders."[17]

Accidents due to structural defects in factories.

The remedies suggested are that close examination of structures must be insisted upon, and the municipal laws must be wide enough to control the erection of buildings in an industrial area. The municipal authorities must submit plans of a proposed factory for the approval of the Factory Inspector and its use should duly be allowed when he has fully approved the construction as safe. The employers must in every case be debarred from making drastic changes in the size of the plant without the certificate of the Factory Inspector about the fitness of the buildings of the factory.

Remedies suggested.

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[15] *Ibid.*, pp. 257—59.

[16] Factory Report, 1923; Bombay.

[17] *Ibid.*, page 18.

Poor lighting and ventilation and general disorder:—

Importance of lighting in factories.

Poor lighting of rooms and corners and passages often leads to many avoidable accidents. A false step in a dark passage-way often means serious or fatal accidents as rapidly revolving shafts and high-speed belts are in motion in some "passage-ways." Dirty windows and dirty walls make a room darker. Every stairway passage or platform must be well-lighted and in cloudy days there should be artificial light. Normal capacity according to Brisco increased 20 per cent if workers changed from badly lighted to well-lighted conditions.[18] Dr. Vernon observed in the munition factories that on an average the night accidents were 17 per cent more than day accidents.[19] Light is thus a prime necessity for efficient *cleanliness and order* in factories, are essential for accident prevention.

Disorder in factories.

Tools, waste material and new products and goods in process of manufacture must not be allowed to litter the floors, otherwise there is danger of accidents. An employee may trip over them and get injury from a fall, or being thrown against moving machinery. The order and cleanliness of the Ford Shops is an ideal of factory arrangement; workers must be severely disciplined for throwing tools or materials in aisles or under moving machinery. 'Order is the first law for efficient work' and accident prevention.

Bad ventilation in factories; Novel ventilation system in Ford workshops.

Bad ventilation increases fatigue and causes accidents indirectly. In Indian factories ventilation is seldom sufficient and workers also care little for it. One of the most noticeable features of the new Ford Shops is their "*Hollow-column air-circulation system*." It consists "in

[18] Brisco: *Ibid.*, pp. 259-260, Lights must not be either too strong or flickering as both are dangerous.

[19] Vernon: Human factor in industry; I.L.R., XIII, p. 681.

the avoidance of all air-pipes gained by making all inside floor-supporting columns hollow with either one or two openings in each hollow column near the ceiling of each room, each column air-opening being covered by an individual damper." The damper regulates the supply of air in all the buildings and air delivery is perfectly apportioned and directed as required. The column openings take air at $1\frac{3}{4}$ inches water pressure at the top from "air-conditions" units.[20] The device seems suitable for big Indian factories.

Air-velocity in factories.

Experts say that the air must move at the rate of 2·5 ft., per minute. In Illinois, the law provides for 1800 cu. ft., of air per hour for each person; and the window and door space on the outside must be 1/8 of the floor space, and these are pronounced as satisfactory minima by experts.[21] The minimum "space allowance" per person should be at 25 cu. ft. in daylight and 400 cu. ft. in artificial lights.

As Pigou has rightly insisted minima for working environment and conditions must be fixed in all important matters of national concern and he specially considers this principle applicable to working conditions in factories.[22]

Temperature in factories and accidents.

Then there remains the question of *temperature*. It is only suitable temperature which enables the worker to do his job efficiently in proper frame of mind. In cases of too high and too low temperature his work is impeded and he cannot meet the precise needs of the machine operations, thus rendering himself open to injuries due to inattention or fatigue. Dr. Haldane discussing the psy-

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[20] Ford Methods and Ford shops—Arnold and Faurote, p. 389.

[21] For all these estimates I am indebted to Dr. Brisco's excellent discussion, *vide* chapters .

[22] Pigou: Lectures on Housing (Manchester University, 1913).

chological effects of various temperatures says 80 degree F. with moderate humidity and 70 degree F. with high humidity cause depression, dizziness and headache and as these are the ranges of temperature in many parts of India where industries are worked, great attention must be paid in India to cooling apparatus being used in hotter parts to ensure efficient work and least possible accidents. The "best working temperature" is found to be 65 to 70 degree F. with an average humidity of 60 to 70 per cent.[23]

Kata thermometer.

In the U. P. the "Kata Thermometer" or comfort-meter invented by Leonard Hill has been prescribed to be used in factories for measuring the relative cooling power of the air, and for keeping readings everyday and readings are often checked; but "ventilating, cooling and humidifying plants" are necessary in all large tropical countries like India.[24] Conditions in India are far from satisfactory.

Cooling and humidifying apparatus in cotton mills.

It is gratifying to note that *Ahmedabad* has recognised the need of "efficient ventilating and cooling arrangements to neutralise the trying climatic conditions of that centre." The reason is ascribed to the increasing realisation by the management of the effects of these improvements in securing "a more contented labour force," and an "increased production."[25]

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[23] *Osborne and Vernon* in their experiments at two large shell and fuse factories during the war found by a long study for 9 to 12 months that least number of accidents occurred at a temperature of 65 degree F. to 69 degree F., I.L.R., 13. 5. 679.

[24] U. P. Factory Report, 1927, p. 6.

[25] Factory Report, 1927, Bombay, pp. 7-8 and 1929..

The mills in *Sholapur* have installed several special ventilating, cooling and humidifying plants that have almost revolutionised the working conditions from the point of view of comfort. The importance of *hygrometer records and temperature records* cannot be too much emphasised and a certain standard of temperature should be prescribed in each city for various industries to ensure the minimum of accidents.[26] We have emphasised the importance of temperature specially for India, as high temperature is generally expected to bring exhaustion sooner and affect the precision of movements thus causing a large number of preventable accidents.

Cooling and recording apparatus in Sholapur mills.

Slippery floors and dirty conditions often cause falls of persons and their getting entangled in belts, pulleys or moving machinery and must be carefully avoided in all corners of the factory.

Slippery floors, etc.

Every factory must be equipped with fire-fighting machinery. Fires cause huge losses and fatal accidents in all countries, and in India fires in cotton factories are common. In Iron and Steel mills great danger from fire may result and cause many accidents.

Fire precautions for preventing accidents.

Section 16 of the Indian Factories Act requires each factory to be provided with reasonable means of escape from fire and the Factory Inspector can require the introduction of any specified devices or measures in factories. Under section 15 the doors of new factories should open outwards. Smoking is also prohibited as well as the use of naked light inside a factory, (Penalty Rs. 200 for offence under each) near "any inflammable material." But smoking must be entirely prohibited by workers and

Indian Factories Act: "Fire" provisions.

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[26] *Ibid.*

superintendents inside a factory by legislation, specially in Textile factories. Old factories must also be required to meet the minimum requirements as soon as possible. Losses from fire in America reached the enormous figure of $225,000,000 in 1912 in spite of many fire devices adopted in that country. Many of these fires are preventable and if all possible devices which can be economically adopted are enforced, many of the fire accidents will diminish to a very small figure.

How to prevent fires?

The problem of fire prevention consists of :—

1. Preventing the origin of fires;
2. Putting out fires after they occur;
3. Preventing the spread of fires.

Combustion is the process whereby substances or individual constituents combine with oxygen and become oxidised with the liberation of heat. Decomposition is slow combustion. Spontaneous combustion is the cause of many fires which is mysterious because it is possible without any external heat. Such spontaneous fires occur often in cotton and woollen mills. The fibrous, porous and finely made materials favour spontaneous combustion because they are always saturated with oxygen. Oils and fats saturated with carbons and oxygen have a tendency to spontaneous combustion. Therefore oil-soaked materials must not be allowed in any factory except in fire-proof iron baskets closed from outside. Damp hay, wet excelsior rags, straw, all favour oxidation and produce spontaneous ignition. Therefore all these and rubbish of all kinds must be penalised in a factory under Indian Factories Act to prevent the origin of fires for which there is no provision yet.

" Openings (in sheathed walls) should all be closed so as to prevent their acting as fire carriers. Sheathed walls

are dangerous." Presence of suspended dust also produces combustion and dusts of all kinds should be removed from factory ceilings, walls and floors. *Automatic fire alarms* should be provided to warn the fire department and *electric thermostats* should be compulsory in textile factories. Pneumatic thermostats are also used and both give alarms at a sudden rise of temperature. "*Safety valves*" and "*manual alarm boxes*" are other useful devices for detecting fires.[27]

Fire drills and fire patrols at least once a week as suggested by the *Industrial Safety Survey* should be made compulsory as likely to minimise accidents from fire during work. Watching efficiently is very necessary and 'Portable watch clocks' recording rounds or stationary watch clocks are very useful.

For prevention of fires "automatic sprinklers" are generally used, but the most efficient one according to Dr. Brisco is John Kenlon's "Automatic sprinkler system" which kills fire in its incipiency. According to one expert 90 per cent of fires in buildings equipped with automatic sprinklers can be held in check, if they are properly installed. Perforated sprinklers (pipe) and fire pails or bucket tanks as used in Indian mills are not so efficient and also crude devices to meet fires.

Other means to prevent fires.

It is also possible to confine a fire to a limited space. There are fire-proof buildings; "walls of brick, stone, cement or metal with floors of cement, stone or brick, with partitions of ceilings, windows, trims and doors of metal or fire

[27]. P. 303: Brisco: *Ibid.* (These technical "fire" details are based on Brisco's excellent discussion).

Also *vide* Watkins: Labour Problems.

[28] In the discussion of Fire Prevention, I have freely borrowed from Brisco and Downey to whom all acknowledgments are made. —*Author.*

resisting material; and with stairways of stone or metal enclosed by fire-proof walls. These buildings should be provided with sprinklers, standpipes and chemical extinguishers. Such buildings will reduce the fire loss to a minimum and prevent heavy tolls of most serious accidents. A *wooden stairway* is a danger to property and life and it must be prohibited in all Indian factories inside and outside as well. There has developed a science of "fire-protection" which deserves careful study by all industrialists.

Accidents mainly due to the carelessness of the employees:—

Lack of training has already been suggested as one of the reasons for causing premature fatigue. The value of a good technical education cannot be exaggerated as a preventive of industrial accidents. Experience and training increase the precision of movements and their regularity and also increase the attention and interest of the worker on account of his understanding of the meaning of his operation and its true function in the whole scheme. He is therefore less likely to receive injuries provided other conditions are good.

"Carelessness": a factor in accidents.

Dr. H. M. Vernon ascribes about 90 per cent of the total accidents to "some sort of carelessness" which is a very rough classification covering various items of carelessness.[29] This is evidently an overestimate. *Loose clothing* is obviously most dangerous and must be strictly prohibited. There is every temptation to use it in Indian summers and it is common in Indian factories.

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[29]. Vernon: Human Factor in Industrial Accidents (I.L.R., XIII).

Workman's inexperience at the job increases the liability to accidents. The following figures from the experience of 88 Illinois firms establish the close connection between the length of service and accidents. 35 per cent of working population in Illinois incurred 60 per cent of total accidents when they had less than 6 months' experience. In another study of 1000 women workers, those with one month's experience injured 18 per cent, those with less than 6 months' experience injured 50 per cent; and about 63 per cent of the total injured had less than one year's experience. The effect of inexperience on total accidents must be more conspicuous in India where illiteracy reigns supreme.[30] Some technical training and "practice" classes must be made compulsory to give the workers "machine sense." "Dummy-machines" have also proved useful in some countries for this purpose.[31]

Inexperience: another factor in accidents.

Ignorance and bad training apart, "false judgments" in the industrial world are fruitful causes of accidents. "On the one hand" says Pigou "workmen overestimate the advantages of the dangerous, unhealthy and fluctuating trades as against safe, wholesome, steady trades and on the other hand they overestimate the advantages of trades which yield a large immediate wage as against trades which yield a smaller immediate wage and more training."[32] The reason for these forms of overestimate is lack of long vision and failure to see the ultimate effects. Dangers of accidents are not seen due to "*overconfidence*"[32] and a subconscious sentiment inherent in most men that they personally are somehow superior to the "average" man situated similarly to themselves. They do not need

False judgments and overconfidence.

30 Report of Illinois Industrial Survey, 1918, quoted by Watkins.

31 Watkins: Labour Problems, p. 602.

32 Pigou: Economics of Welfare, 1920 edition, p. 651.

the machinery to be fenced, their constitution is not so feeble as to be affected by bad conditions. This spirit of "*braggadocio*" and a general belief in *their own* "*good fortune*" cause many accidents.[33]

Machinery Accidents.

According to expert opinions of Dr. H. M. Vernon and Watkins most of the accidents are due to carelessness and lack of proper appreciation of dangers. General confidence of workers in their super-normal skill and good fortune makes them oblivious of most dangers and accidents in the extra-hazardous industries.[33] Those resorting to dangerous trades and risky industries are as Downey proves "*in* the prime of life" and their youthful exuberance often leads them astray.[34] Lack of judgment and forethought coupled with inexperience and lack of training in this group in many cases leads to indiscretion at the jobs and accidents thus increase enormously.

General causes of accidents in the case of young workers.

"Nearly all the factors are ultimately human in origin but it is useful *to draw a distinction* between those which are due directly to the subject who suffers the accident because of his own carelessness, lack of knowledge or lack of skill and those which are caused indirectly by his employer or some one else in authority because of the dangerous conditions in which he carries on his work. Accidents due to unguarded machinery would fall in this class but probably they form but a small portion of the whole."[35]

A distinction.

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[33] Pigou: Economics of Welfare and H. M. Vernon: Human Factor and Industrial Accidents, I. L. Review, Vol. 13 (5th May, 1926), p. 674.

[34] Downey: *ibid.*

[35] *Ibid.*

Out of 162,154 factory and workshop accidents in Great Britain only 53,941 or *a third* of the whole were attributed to *machinery*, and not more than 35 per cent of these machinery accidents were caused by absence of safeguards. "Hence it was concluded that the provision of more adequate safeguards could be expected to cause a reduction of not more than 10 per cent in the accident rate. The remainder of 90 per cent were due to inexperience, inattention or inappreciation of danger—which are difficult to disentangle from each other." Statistics have clearly proved that machinery accidents are less than $\frac{1}{3}$ of the total and they are "probably the more serious cases," therefore receiving special attention of inspectors. An examination of the latest Bombay and the United Provinces factory reports shows the same tendency in India but as safeguards and devices have not been yet so widely adopted in India the number of machinery accidents is much greater in India.

Causes of accidents in Great Britain.

"The first and most urgent work of the inspectors is to bring constant pressure to bear with a view to improve standards of safeguards and safety."[36] One of the methods of achieving this object is that of "agreements" between employers and workers defining the safety measures to be adopted and mutual obligations of the parties concerned like the Sheffield Rolling Mills Agreement.[37] This is not the case in India but if it is found practicable to adopt this system, it would be useful in reminding operatives of their duties and increase the use of safeguards and devices often neglected by workers.

Influence of factory inspectorate in reducing accidents.

[36] Bellhouse: Factory Report, Great Britain, 1918.

[37] Annual Report, Chief Inspector of Factories, Great Britain, 1922 (I. L. R., Vol. 9, 667).

The problem of Factory Inspection received special attention at the 5th session of the International Labour Conference which defined its sphere of action. One of the recommendations of the conference was to appoint only those as factory inspectors who were technical experts "that in view of the difficult scientific and technical questions which arise under the conditions of modern industry in connection with processes involving the use of dangerous materials, the removal of injurious dust and gases, the use of electrical plant and other matters it is essential that experts having competent medical, engineering, electrical or other scientific training and experience should be employed by the state for dealing with such problems."

Efficiency of the factory inspectorate.

But one difficulty is to ensure that general technical training of inspectors however thorough may keep pace with continual changes in technical processes in increasing specialisation. In course of time therefore it may be necessary to carry technical specialisation in the inspectorate to a much higher point than is generally found necessary at present. The number of the inspectorate must not be unduly increased to have too many and repeated visits of the same factory by different inspectors. The creation of a *Special Health Service* is very desirable. The employer is protected by one of these recommendations from "disclosing the industrial secrets." Inspection is also permitted by accident insurance institutes interested in the factories.

I.L.O. suggestions.

In India the technical qualifications of inspectors are generally good, but few of them have any medical experience which is desirable. Women inspectors are few, and they should be specially charged to inspect factories with a large number of women workers. Industrial diseases are seldom emphasised in India probably because of the

medical inexperience of the inspectorate. There is a most regrettable lack of proper co-ordination and uniformity between the factory inspection and reporting in various provinces due to the want of a Chief Inspector of Mines for the whole of India as there is one for the whole of Great Britain. The great importance of a Chief Inspector for the whole India cannot be too highly emphasised.

IV. THE PROBLEM OF INDUSTRIAL FATIGUE

Psychic factor and accidents.

Tasks in various industries are not scientifically planned and adapted to the capacity of each worker, and hours are arbitrarily fixed by employers or by legislation. The tendency in all industrial countries has been to attempt a gradual reduction of working hours. Still hours are considered too long by many students and it has been definitely suggested by Schulze-Gavernitz and some others that industrial efficiency and productivity even, will increase by a reduction of hours.[1]

A vast experiment.

Let me quote the latest example, that of Soviet Russia; and examine the effect of reduced hours on productivity. The 12 and 14 hour day of pre-revolutionary Russia was abolished immediately by the Soviet Government and *8 and 7 hours* for day and night workers were prescribed as *maxima* for manual work; and *5 and 6 hours maxima* for night and intellectual workers, with a *weekly rest* for all workers of uninterrupted 42 hours.[2] This is a most astounding and vast experiment of reduced hours by a whole nation, if we accept the facts substantiated by Hardy and Nearing. A *fortnightly annual vacation* with full pay *after* $5\frac{1}{2}$ *months' work* is also prescribed and *overtime* is ordinarily not permitted. Yet the "index of productivity," 100 in 1922, rose to about 210 in 1926 if figures are correctly given, which allowing for other changes

[1] Hobson: Evolution of Modern Capitalism.

[2] Hardy and Scott Nearing: "Economic Organisation of the Soviet Union," 1927 (page 170).

of scientific planning, is nevertheless marvellous and speaks much in favour of reduced working hours.[3]

Long hours and absence of relaxation must result in fatigue, exhaustion and flagging of attention and each of these obviously tends to increase the possibility and frequency of accidents. Long hours are positively injurious beyond a certain point in their effect on the total output as was found out in England by many industrialists during the War.

Bad effects of long hours on output.

"After the first feverish rush it was found that in at least two important districts (Leeds and Glasgow) employers refused to allow overtime even though the men were willing to work." The experience of a crown factory is said to be that "any lengthening of the day beyond 6 P.M. and a total of $8\frac{1}{2}$ hours' work daily, exhausts the workers and is of no advantage in increasing output."[4]

English examples.

It was found by a wholesale clothier employing a thousand women on Government contracts that any work beyond 8 A.M., to 8 P.M., "is quite useless, it exhausts the workers and does not pay."[5] Another factory with 2000 women and girls is quoted by the Factory Inspector in 1914 as reducing the hours from 7—6 to 8—5 and "output remained the same."[6] "This firm have been working overtime continuously for some months" a firm is quoted reporting, "but have found it absolutely necessary to stop it for a week as the strain

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3. *Ibid*: See the diagram on p. 171 on "Dynamics of Productivity (Hardy and Nearing: *Ibid.*).

N.B.—In view of conflicting evidence it is not safe to rely on the facts about the conditions in the Soviets for any scientific conclusions, despite the valuable testimony of the learned authors, though economic progress of modern Russia is undoubted.

4 Proud: Welfare Work, p. 152.

5 Factory Inspectors' Report, 1914, Great Britain.

6 *Ibid.*, p. 57.

was becoming too great and the number absent through illness was so large."[7]

Similar things happened in the woollen and worsted industry. We have therefore good ground for concluding that long hours and overtime are generally injurious to total output, *after a certain point* and are positively harmful by causing the nervous exhaustion of the workers. They increase their liability to accidents and make them more prone to diseases. If the hours are long and there are no proper rest pauses workers are found staying longer in dirty latrines to recuperate from the effects of exhaustion. "That they do sometimes stay longer in these places than necessary, is of course well known to me, but to my thinking it only shows how great the strain is on women and girls that they should desire rest so obtained."[8] "It is normally cheaper for an employer to run his machine 9 hours instead of 10 for the same output" but the effect of short hours on workers depends on the absence of speeding up, and a provision of proper rest pauses.

"It is inconceivable" says Miss Proud, "that with properly adjusted intervals for rest it is less strain for a worker to produce the same quantity in a nine-hour day than in a ten-hour day."[9] Excessive strain fatigue and nervous exhaustion have a bad effect in worker's efficiency and national productivity in which the employers, employees and the nation are all interested. As these causes increase accidents and human loss, employers are made to compensate at great cost for the extra injuries beyond the normal limit, suffering huge economic loss which they shift to the community. The community must therefore see that accidents are kept at the lowest possible point

Effects of Fatigue and nervous strain of the nation.

[7] *Ibid.*

[8] Factory Inspectors' Report, Great Britain, 1913, p. 81.

[9] Proud: Welfare Work.

by enforcing as short hours in industries as possible and provide proper rest pauses and limits of overtime.

Fatigue and exhaustion. Fatigue is "a sensation, the result of work carried beyond the capabilities of organism."

Definition of Fatigue.

All muscular movement causes "oxidation" which throws toxic impurities of a poisonous character into the blood. After a certain point further addition of these is injurious and a feeling of fatigue is nature's signal "to cease the accumulation of further waste products." If this warning is not heeded and "movement" is continued, exhaustion or overfatigue follows and death may come in at a further stage. Exhaustion makes the muscles immediately "rigid" and "putrification starts." "Work is performed at the expense of nutrients stored within the muscles and of oxygen absorbed from the blood" and when this reserve force is consumed precaution to restore the reserve force by sufficient recuperation is essential.

Effects of Fatigue on the organism.

"The toxic impurities produced during work circulate in the blood and act upon the nerve endings in muscles and upon the grey matter of the brain. They diminish the contractibility of the muscles and render them less responsive to nerve stimuli by poisoning the large nerve cells in the grey matter of the brain."[10] The result is that attention flags and the rhythm of movement becomes less regular. "Headache is the sign of brain fatigue and sleepiness that of the physical" and both these are sure to increase the number of accidents.

Fatigue reduces the power of the brain to "remit volitional impulses" and hands and fingers easily slip into dangerous portions of the machinery causing serious injuries to limbs which leads to enormous compensation claims. (For the loss of hand, the equitable compensation

[10]. Brisco: Economics of Efficiency, pp. 180—83.

is said to be 50 per cent of wages as the rate for life pension.)[11] The flagging of attention diminishes precision of movements and is one of the great causes of accident.[12] "There is an immediate relation" says Dr. Brisco, "between fatigue and industrial accidents. Experts have proven that the greatest number of accidents occur between 10 and 11 in the morning and 3 and 4 in the afternoon"[13] just when workers are a little over the middle of the work spell.

"Long hours and overfatigue are two important factors of inefficiency and leading causes of accidents."[14]

Fatigue and Accidents.

"*Speeding-up*" the result of Taylorism or piece-work and overtime bonuses is sure to bring fatigue and exhaustion without proper precautions[15] and they are likely to increase accidents, and inefficiency also in some cases as was Britain's experience during the War.[16] "Scientific management" and overtime must therefore be kept within strictest limits if accidents are to be reduced.

How to diminish fatigue? The body purges itself of toxic impurities during repose and if scientifically regu-

How to diminish fatigue?

lated rest pauses are provided the toxic accumulations are normally burned up by "oxygen brought from the blood excreted by the kidneys, destroyed by the liver and cast off from the body through the lungs."[17] An important factor in efficiency and accident prevention is precautions "to make certain that recovery through rest is complete."

The efficient cycle should be, work to the period of sensation of fatigue and sufficient rest to repair the body

11 Downey: *Ibid.*, p. 52, Schedule.
12 Brisco: Economics of Efficiency, p. 82.
13 *Ibid.*, p. 188.
14 *Ibid.*, p. 263.
15 Pigou: Economics of Welfare.
16 Factory Inspection Report, 1914, G.B.
17 Brisco: p. 183.

of its losses.[18] Relaxation and amusement are important factors in increasing efficiency and the power of resistance to the toxic impurities. Training and technical education of the worker also increases this resistance power and postpones the "point" of fatigue by increasing the ability to work longer.

Real and false fatigue.

It is hard in many cases to distinguish between *real and false fatigue*. William James says "We live subject to arrest by degrees of fatigue which we have come only from habit to obey. Most of us may learn to push the barriers further off and to live in perfect comfort on much higher levels of power."[19] Many persons acquire the habit of easy surrender to fatigue, and training will push the barrier further.

Periods of work and relaxation must be arranged in the right cycle by a careful study of the climate, the nature intensity and environment of work and the racial qualities of the workers and no hard and fast rules can be laid down. Everything done to reduce fatigue like good sitting arrangement when work permits it and delivery of sufficient tools, and materials direct to the worker by automatic feeds, should be encouraged. It is likely to improve his productivity and lessen chances of accidents.

Anything which tends to bring lack of *co-ordination between the speed of machinery and the precision of muscular movement* will tend to increase accidents.

Alcoholism and fatigue.

Alcohol and stimulants as antidotes to fatigue are commonly justified by ignorant workers and in India the curse of tobacco is also rampant for similar beliefs. But these stimulants do not increase resistance to the toxic impurities but really diminish it. The use of toddy and

[18] *Ibid.*, p. 183.

[19] William James: "Energies of Man" (An essay).

arrack in Madras has been found to have a deteriorating effect and its sale about the factory has been lately stopped by the Welfare Committee of the Buckingham and Carnatic Mills.[20] Stimulants generally speaking diminish efficiency whatever the belief of the workers. They only have a psychological value to certain extent and in most cases tend to diminish the fatigue-resisting power and their productive efficiency.

The sensation of fatigue may temporarily be driven away by drinks—alcohol, toddy, beer, etc.—but it is in the end a greater drain on the reserve force as is proved from the protracted experiments of Dr. Voionama published in the I.L.R. Stimulants are like a whip in that they urge on the muscles and cause more rapid contraction.[21] The extra drain resulting from drinks requires a longer period of recuperation to drive fatigue and the worker is often put in an abnormal frame of mind "causing uncertain muscular control;" it "frequently leads directly to accidents and injuries."[22]

The "efficiency" movement has put a ban on the use of alcoholic drinks in or about a factory. According to some authorities, beer and certain other types of liquor stimulants are not positively injurious if taken in "moderate" quantities. But this "moderate" dose often proves illusory in practice and is seldom adhered to. In any case it is almost safe to say that most of the liquor stimulants seem in no way positively useful in their effect on the nerves and physical strength of the worker, though they may not be positively harmful in their immediate results.

[20] Buckingham and Carnatic Mills, Madras, Report on Welfare Work, 1927, p. 4.

[21] Brisco: "Economics of Efficiency" and I.L.R., 1927,—article by Dr. Vernon.

[22] Brisco: *Ibid.*, Chapter on "Working Conditions."

Tobacco and "*charas*" and "*ganja*" must be strictly prohibited inside all Indian factories. Temperance lectures and clubs and the provision of cheap nourishing refreshments will considerably increase the efficiency of the Indian workers and remove these bad habits in so far as they are due to ignorance to a great extent.

Tobacco and *charas*.

THE PROBLEM OF FATIGUE, IN RELATION TO INDUSTRIAL EFFICIENCY AND CAUSATION OF ACCIDENTS

The phenomenon commonly known as fatigue has an intimate causal relation with industrial accidents and therefore has serious repercussions on industrial efficiency. In fact the study of industrial accidents in its psychological aspects is in the main concerned with investigations into the causes of fatigue and its reactions on the working capacity of the labourers. Therefore some discussion of the phenomena known vaguely in popular parlance as "fatigue" and "efficiency" is necessary in order to appreciate properly the problem of Accidents.

Fatigue in relation to accidents.

Fatigue may be considered as a physiological or as a psychological factor; but the initial basis of fatigue is physiological; and its psychic effects which mar a worker's efficiency are the sequel of the physiological changes which induce fatigue in the working organism.

To understand the physiological structure or "chemistry" of fatigue we must know something of the functions of the body and the chemical changes which appear internally while the body is engaged in activity. "The structural basis of all tissue, muscular, nervous or connective is the cell, and the life of the tissue consists in chemical combination of protoplasm or substance of the tissue cells

'Chemistry' of fatigue.

with the nutritive materials derived from food-stuffs and the oxygen of the air. The destructive property of the cell that indeed which makes it living is the power of taking to itself and converting to its own substance materials which are not living."[23]

This double process, the casting off and working up, goes on simultaneously, as Sir Michael Foster, once graphically described, "some of the capital of the living material is always being spent, changed into dead waste, some of the new food is always being raised into living capital."[24] There are therefore two contradictory processes —assimilation or Anabolism, and dissimilation or Katabolism. The combination of these two processes *in certain ways* results in Metabolism or life-process which is theoretically the result of an equilibrium. "It is in these metabolic changes and the disturbances in metabolic balance that we must turn for a true explanation for the phenomenon of Fatigue."

"As soon as metabolic balance is destroyed, the organism becomes clogged with its own poisons, exhaustion results and health is impaired. The physiological normal phenomenon of fatigue becomes pathological or abnormal exhaustion. Health, even life itself depends on the metabolic balance."[25] Hunted animals drop dead on the chase on account of sheer effects of the self-generated toxins produced during intense activity. "Poisons are more and more heaped up" says Foster in this connection, "poisoning the muscles, poisoning the brain, poisoning the heart, poisoning at last the blood itself, starting in the intricate machinery of the body new poisons in addition to

[23] Goldmark: Fatigue and Efficiency, p. 11.

[24] Sir Michael Foster: Weariness, Rede Lecture, Cambridge University, 19th Century, xxxiv, 199.

[25] Goldmark: *Ibid.*, p. 200.

themselves."[26] The 'hunted hare run to death dies, . . . because a poisoned blood poisons his brain, poisons his whole body.' In such animals the blood is found 'loaded with chemical action;' and death is followed with "abnormally rapid putrification and rigidity of the muscles."[27]

With men such death from over-exertion is rare in modern times. Professor Peirraccini, an Italian pathologist, gives two good examples from Algeria, two Algerian runners fell dead on arrival, one after covering 192 kilometers in 45 hours, the other 252 kilometers in 62 hours. Abnormally rapid putrification and muscular rigidity after death were noted, and death was declared to be due to the "excess of fatigue."

"A tired person" as Miss Goldmark has remarked "is literally and actually a poisoned person, poisoned by his own waste products. But so marvellously is the body constructed, that like a running stream, it purifies itself, and during repose these toxic impurities are normally burned up by the oxygen brought from the blood, excreted by the kidneys, destroyed by the liver or eliminated from the body through the lungs."[28] These toxins of fatigue can be subjected to chemical analysis in laboratories and their nature has been thoroughly ascertained. Metabolic poisons in one set of muscles also affect other muscles.

Similarly they also act on our nervous system—on nerve endings in muscles and the central nerve cells. There is a metabolism of the nervous system itself. So the nervous fatigue is ascribed to the same double origin as muscle fatigue-accumulation of toxic waste and consump-

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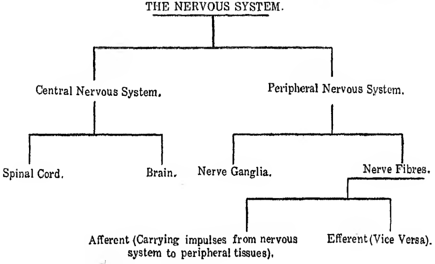
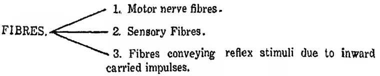
[26] Foster Sir Michael: Weariness, Rede Lecture, Cambridge University, 19th Century, Vol. 34, p. 1.

[27] Peirraccini: Patalogis del Laboro: Milan, p. 18, 1906, quoted by Goldmark.

[28] Brisco: *Ibid.*, ante.

tion of energy-yielding substance.[29] The fatigue in our complicated nervous system cannot be so easily measured and registered as muscular fatigue upon a revolving drum.





Some scientific details.

"There is profound disagreement among scientists as to what part of the nervous system first succumbs after excessive exertions. Nerve fibres—carriers of energy—are not readily subject to fatigue." "Varied experiments have proved that their normal functional activity may be carried on to indefinite extent without causing fatigue." In this experiment the passage of nerve impulse to the muscle has to be blocked somewhere. By the use of *Curare*, a South American arrow poison, the passage of the electric

[29] Howell, W. H.: Text-book of Physiology, 1908, as quoted by Goldmark.

stimulus to the muscle is blocked, the poison affecting the terminations of the nerves or motor end-plates and preventing their transmission of impulses to the nerves."[30] "By the use of curare then the sciatic nerve has been continuously stimulated for as long as ten hours." When the effects of curare were removed (in a few minutes only) the nerve was still found functioning and the muscle responding.[31]

The Newman Committee on Fatigue observe, "In the conducting nerve fibres fatigue may be said not to occur" and it is not discernible and the recovery may be too quick though the other two "the initiating and distributing" nerves of the brain and spinal cord are more quickly fatigued than the contracting muscles."[32]

"We have experimental evidence" says Dr. C. S. Myers, Director of National Institute of Industrial Psychology, "that whereas nerve fibres are virtually indefatigable, the end-plate—the structure in which nerve-fibre terminates at the muscle fibre—is more readily fatigued than the muscle fibre itself, blocking the transmission of the impulse from nerve to muscle at a time when the muscle fibre is still responsive to stimulus applied to it directly."[33] After protracted muscular activity the brain and spinal cord tire first before the muscle. "Thus after a finger-muscle has become so fatigued by the egrograph that it can no longer lift a given weight it can be made to do so by electric stimulation. The muscular mechanism is still in working order at least for a space of time." "After some time even this electric stimulus can-

[30] *Op. cit.*, p. 111.

[31] Goldmark, *op. cit.*

[32] Newman Committee Report on Fatigue, Memo., Ministry of pp. 37—39.

[33] C. S. Myers: Industrial Psychology in Great Britain, pp. 37—39.

not contract the muscle . . . apparently the muscle has not entirely lost its power of contraction when it can no longer materially contract. According to this theory what seems to be muscular fatigue is in reality nervous fatigue"[34] "It is well-known that a man apparently run to a stand-still . . ." may upon some new excitement in a race run freshly again under augmented stimulus from the nervous system."[35]

Some fatigue experiments by Mosso and Hodge.

According to *Hodge* demonstrable histological changes take place in the brain and the spinal cord of animals after prolonged activity, as is clear from laboratory experiments. *Mosso* drew the attention to marked modifications in the brains of exhausted birds and describes the results of his fatigue tests on military carrier pigeons of the Italian Ministry, and also of his study of wearied birds who come to the Italian shores each year from Africa in large numbers, hundreds of whom are killed exhausted by their journey, dashing themselves in plain daylight against walls and houses.[36] "Mosso considered their impaired vision due to cerebral anæmia found in birds exhausted by long flights. Mosso shows later in his treatise that the diminished circulation of blood affects the functions of the nervous tissue in man."[37]

"A few seconds pressure of eyelids lessening the blood-supply is enough to distort vision and a "diminishing of the brain's blood-supply is followed by loss of

[34] Goldmark, *op. cit.*, p. 30.

[35] Newman Committee Report on Fatigue, Memo. 7, My. of Munitions.

[36] Hodge, C. F.: America. Journal of Psychology, 1887-88, Vol. 9, 1; p. 479.

[37] Mosso, Angelo: La Fatica; Milano, 1891, Eng. Trans., pp. 1...29, 72-3.

consciousness after six or seven seconds."[38] Other more recent investigations throw some measure of doubt upon this fatigue of the central nervous system, says Goldmark, but she is a bit back-dated in her views, though the precise location of the nervous fatigue is a matter of great uncertainty.

Comparative fatigability of different organs and nerves.

According to some investigators the part to tire first in our neuro-muscular mechanism is the nerve-ending in the muscle or the motor end-plate.[39] *Dr. Myers* seems to agree with this view. "Yet it must be understood that the uncertainty of scientists as to the precise location of nervous fatigue does not touch the acknowledged fatigability of some portion not yet completely verified of our nervous endowment." Thus Professor Frederic Lee who most strongly inclines to the view that central cells are more resistant than has been supposed, specially states that "nervous fatigue is an undoubted fact" and that we cannot deny fatigue to "psychic centres" though the "intimate relations of central and peripheral fatigue are much in need of exact experimental study."[40]

Nervous fatigue an undoubted "fact."

For our purpose it is enough that nervous fatigue is an "undoubted fact," be it central or peripheral, as a "relentless fact, reacting inexorably on our total health and life."[41] It is the form of fatigue most fraught with mischief for when fatigue affects the nervous system it

[38] *Ibid.*

[39] Muller, G. E.: Zeitschrift fur psychologie und pysiologie der sinnesorgaane, 1893, Vol. IV, p. 122.

[40] Cf. Storey, T. A.: Amer. Journal of Psychology, Vol. 8 1903, p. 355, and Joteyko, Mlle, Fatigue; Richet Dictiony. de psychologie; Paris, 1914.

[41] Harvey Lectures: Lee, 1905-6, p. 180.

attacks what has been called " the administrative instrument of the individual " which as Goldmark says " directs, controls and harmonises the work of the parts of the organic machine and gives unity to the whole."[42]

According to Sir George Newman, " Fatigue is the sum of results of activity which show themselves in a diminished capacity for doing work."[43] This definition of fatigue is a bit too wide for a diminished capacity for doing work may be the result of other factors external and internal which may not necessarily be due to any physiological and nervous changes in our system. The Newman Committee emphasised that " bodily sensations " are a " fallacious guide to the true state of fatigue and a very inadequate measure of it." Fatigue in its true meaning advances progressively and must be measurable at any stage by a diminished capacity for work, before its signs appear plainly or at all in sensation."

Newman's idea of fatigue.

Fatigue in its essential feature is not the sequel of " the simple using up ' exhaustion '—of substances supplying the chemical energy, liberated during work, but upon the accumulation within living elements of the products of chemical changes involved." " Fatigue of the animal machine is not to be compared to the factor of fuel in the steam-engine or with the run-down of a clockweight, but rather with the clogging of the wheels in some mechanism by dust."[44]

Activity in the human body is the result of changes in three groups of parts—" first the complex nervous mechanism of the brain, concerned in the initiation and

[42] Goldmark, *op. cit.*

[43] *Ministry of Munition* Report on Industrial Fatigue by Newman Committee (of Experts): Memo. No. 7.

[44] *Ibid.*

distribution of impulses to action; second, the nervous, which conducts the impulses to muscles and third the muscles themselves which by contracting finally perform external work."[45]

We have already considered muscular fatigue in its various aspects and we shall now turn to *nervous fatigue and psychic fatigue*. We must however beware from making any strict compartments between the muscular and nervous fatigue. "We cannot get definite limits where nervous fatigue ends and muscular begins and *vice versa*." They are inevitably bound up together, since every muscular act is due to the stimulus received through the nervous from the central nervous system.[46] We know little of the nature of the nerve impulse, or energy except that some form of electric activity is involved. Though the origin of the nervous impulse is shrouded in mystery, it is certain that the level of "nervous endurance and resistance" will be lowered by "excessive pressure" upon them.

Nervous and psychic fatigue.

"Nervous energy" says Goldmark "is not only the stimulus of muscular action, but the controller of all our functions; the very pulse of the machine." Hence nervous fatigue and exhaustion is the most destructive because the most inclusive form of fatigue.[47]

According to the Newman Committee, "fatigue is not clearly associated with the muscles." "The fatigue is the fatigue of the nervous system, though in sensation its effects may be referred to muscles themselves."[48] The

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[45] *Ibid.*

[46] Goldmark: *op. cit.*

[47] Goldmark: *Ibid.*

[48] Newman Committee Report on Industrial Fatigue: Memo. 7, (Ministry of Munitions).

real "problem of fatigue" is that of the "fatigue of the nervous system and its direct and indirect results."[49]

Industrial and Mental Fatigue.

Industrial Fatigue is the most pervasive type of Fatigue though it differs of course in various industries according to the intensity and length of the operation and the type of work involved. Industrial Fatigue affects the workers' muscles, nervous system and the mind. In muscular fatigue, too much concentration of lactic acid is the chief factor, and its too much concentration prevents its reconversion into Glycogen.[50]

In Nervous Fatigue, "the end-plate in which each nerve terminates at the muscle fibre becomes unable to transmit from the nerve to the muscle the impulse which alone can initiate activity." It must be noted however that nerve fibres themselves are virtually indefatigable.[50]

In Mental Fatigue the tired mind sometimes loses control of its less amiable thoughts and feelings, and gives vent to repressed sentiments and ideas. There is worry, irritation and boredom; and if there is no relaxation or relief by a rest-pause, it may result in "general listlessness and *ennui*."[50]

According to Myers, *Industrial Fatigue* is due to "inhibitory nervous impulses ascending from the muscle to the Central Nervous System." Some of these ascending impulses affect consciousness in the form of discomfort, pain or cramp, and others only prevent voluntary movement, and result in preventing the delicate co-ordination of movement.[51] It is so very difficult to exactly define

[49] *Ibid.*

[50] Industrial Psychology: Home University Series, pp. 61—64 and Knight by Myers. Knight's article in the above book, p. 63.

[51] C. S. Myers: Industrial Psychology in Great Britain.

Industrial Fatigue, as it is a complex phenomenon, depending on the varying effects of psychic factors, like incentive, excitement and nervous suggestion. Of its effects we have much evidence and knowledge, but not so of its intrinsic nature. Useful results have been obtained by Researchers by the study of the curve of output, minute by minute or every five minute for an hour or more. According to Myers, this has shown the presence of various psychic factors which he classifies as follows:—

(*a*) "*Incitement*" or initial incentive with which the work begins and which affects the intensity of the work at the start.

(*b*) "*Settlement*"—the warning up of the subject to his work after he has been withdrawn from it, the recovery of lost rhythm and neglect of distracting conditions.

(*c*) "*Spurts*"—of which "the most striking are the *initial spurt* when the subject starts fresh to his work, and the *end spurt* when he realises that the end of his work is approaching."[52]

There also are found at times *temporary* "*depressions*" which result in loss of efficiency for causes other than fatigue, for instance, domestic worries, etc.

Knight says in his excellent paper on "Work and Rest" that the only safe guide in diagnosing Fatigue is the WORK CURVE—a graph showing variations in workers' efficiency from day to day, week to week, or hour to hour. "The so-called direct tests of Fatigue are of little use. They are all vitiated by the fact that we know so little about the essential nature of Fatigue."[52]

There are certain important objections against the general applicability of these experimental results to actual industrial life. Conditions of the laboratory under controlled conditions are far removed from work-a-day

[52] Myers: Industrial Psychology in Great Britain.

life. "The movement of an egrographic subject are most forceful and extensive to the widest point," and this is not so with an ordinary factory worker. Then muscular fatigue in a factory cannot be isolated from factors like "skill and intelligence" which depend on the proper working of the higher nervous system. Then there may be a fundamental objection which should eliminate this fatigue factor somewhat. "The ordinary worker regulates his energy according to the period he has to work and his output is regulated according to his anticipations of Fatigue."[53] The last point however is not really of much intrinsic importance, for no worker generally makes such a deliberate calculation in regulating his speed of work, which is governed very much by the atmospheric conditions and the type of supervision in the factory. Despite these objections which must be made allowance for, in applying the results of Fatigue Research to a particular industry, we have to depend on the results obtained from typical cases. We have to remember that the results must require modification with any changes in the concrete conditions which obtained under the original observation.

Time of Accidents.

Hourly frequency of accidents and fatigue.

The distribution of Accidents according to time of the day, or the diurnal frequency of Accidents is a very interesting and fruitful study. It specially indicates the working of fatigue and other psychic factors, so far as they affect the workers' efficiency and consequently the industrial output. The various studies of the diurnal and hourly variations of accidents show "considerable resemblance to one another. In this connection one cannot dispense at present with the special study of these accident variations according to hours of the day made by

[53] Myers: Industrial Psychology, H. U. S. and Knight, p. 64.

Dr. Vernon, in the Shell and Fuse factories for a very long time during 1915 and 1916.

"In the morning spell of work which usually lasts $4\frac{1}{2}$ or 5 hours the accidents occurring in the first hour" says Dr. Vernon, "are infrequent. In succeeding hours they rise rapidly till they reach a maximum in *the last hour but one* of spell, whilst in the last hour they may fall off somewhat. This fall is due partly or wholly to the fact that the workers are apt to knock off a few minutes before the end of the spell and make preparations for departure. Hence we are justified in saying that having regard to the work done, the accident frequency tends to increase throughout the morning work spell, and it may be two to four times greater towards the end of the morning than it is at the beginning."[54]

Morning spell.

"In the afternoon work spell," continues Vernon, "it is steadier than in the morning but usually it starts rather low in the first hour, works up to a maximum in the middle of the spell and then falls off." It has often been considered that these variations are due chiefly to Fatigue factors; but on careful study of the data it is difficult to account for these variations in accident frequency by suggesting Fatigue to be the prime cause. Because, as Vernon suggests, this Fatigue must increase gradually during the course of each work spell and "the beginning of the next may be due to the recuperative effects of the meal hour. Undoubtedly most industrial workers do get moderately fatigues by their daily round of work, but it appears that as a rule, this Fatigue is not sufficiently marked to account for more than a small fraction of the diurnal rise of accidents." "This statement" observes Vernon, "is substantiated by observ-

Afternoon spell.

[54] I. L. R., Vol. XIII/5, Vernon's article; Human Factor in Industry, pp. 674—84.

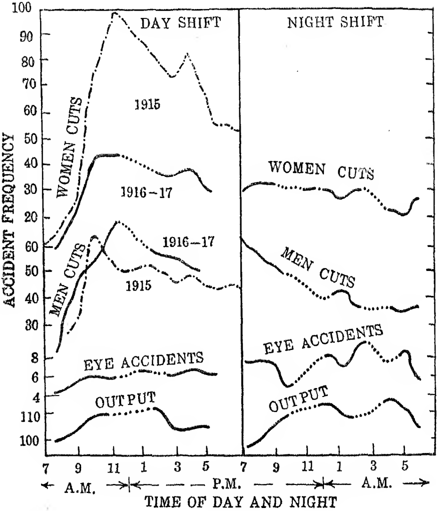
ing what happens to accident frequency when the workers are on night shift instead of on the day shift."

During the Great War, there were various opportunities for making controlled observations in the Government Factories, and we give below the results of some very important investigations made by Dr. Vernon at a large Fuse Factory having 10,000 workers during the Statistical period 1916-17, working during the Day Shifts for a 5 hours spell, and in the Night Shift for three spells of work of $4\frac{1}{2}$, $3\frac{1}{2}$ and 3 hours each. A regular study of the cuts and injuries during this period indicates that there were 13,251 cuts and 1,772 Eye injuries. "They were at a minimum at the beginning of the morning spell, and rapidly rose till they reached a maximum at the end of it. They did as a matter of fact fall off during the last few minutes; but in these data the accidents occurring during the first and last hour have been ignored, because they were influenced so much by the workers not having settled properly to work. In the afternoon spell the accidents were more numerous than in the morning and they first rose and then fell in the men though they fell steadily in the women."[55]

During the night shifts the accidents were not at a minimum during the first work spell (as in the day shifts); but they "were at or near a maximum and then gradually fell." "They continued to fall for most of the night, and in the last work-spell were only two-thirds as numerous as the first work-spell. That is to say that the very same workers when they changed from day to night shifts, showed a complete reversal of accident frequency." Similar results were observed with other groups of Munitions workers in England and America.

[55] H. M. Vernon: Human Factor in Industry, I. L. R., Vol. XIII/5, pp. 676—80.

We are plotting these results of the Statistical studies of Dr. Vernon in the Diagram below.



(With full acknowledgments to Dr. H. M. Vernon, and International Labour Review.)

Vide: Vernon's diagram and article, I. L. R., Vol. XIII, V. "Human Factor in Industry."

Vernon's explanation of these contradictions.

Dr. Vernon's explanation of these " apparent contradictions " suggests that the reason is to be found in the *psychic state* of the workers. " When they came on a day shift, they were in a dull and lethargic condition, as they had only recently got out of bed, but they brightened up during the course of the morning as they usually had a cup of tea after two hours of work and they had their dinner break to look forward to. Consequently they became more careless and inattentive and accidents multipied. During the night shift, on the other hand, they got up three or four hours before they were due at the factory and spent these hours in relaxation and amusement and in having a substantial meal. Consequently they came to the factory in a lively and excited state and the carelessness thereby induced caused a maximum of accidents. They calmed down during the course of the night as they had nothing but breakfast to look forward to, and accidents consequently diminished." This explanation of Dr. Vernon seems to be very plausible and clever; but it requires confirmation from the results of other investigators in other factories as well. After all this psychic phenomenon is in no way peculiar to the Shell factories. If Dr. Vernon's idea is fully corroborated on scientific grounds, it would suggest some re-arrangement of factory hours in the interest of the workers.

Psychic factors.

Day and Night Shifts: peculiar psychic conditions.

Fatigue factor in accident causation.

Again according to Vernon, *Fatigue* does not play much part in accident causation; and for this conclusion he relies on these diagrams based on the 1915-16 and 1916-17 Statistics in the Shell Factories. " In 1915," he says "operatives working for 12 hours a day, instead of 10 (*i.e.*, for $4\frac{3}{4}$, 5, and $2\frac{1}{4}$ hours' duration)," specially

"MEN suffered fewer cuts—hence they cannot be greatly fatigued by excessively long hours of work. With WOMEN it was different—for long hours threw them into a state of excessive fatigue.[56] It will be seen from the diagram that though their accident frequency was about the same for the first two hours as that observed subsequently during the ten hours, it rapidly mounted during the latter portion of the work spell; and on an average for the whole work it was nearly three times greater than in the ten-hour-day period. As an indication of the Fatigue of the women it may be mentioned that during the 12-hour-day period they were treated for faintness at the factory nearly nine times more than the men, while in the subsequent ten-hour period they were treated only three time more frequently." Results of observations at some other factories seem to confirm Dr. Vernon in his conclusions, that "accident frequency in women was increased by long working hours, that in men was little affected." But the experience of a fuse factory in America engaged in muscular work showed a greater increase of accidents as the day advanced than in the case of machine workers. Therefore Vernon suggests that probably his conclusions may not be applicable to muscular work where fatigue is an important factor due to the harder work. He emphasises that in machine industries where hours seldom exceed 48 hours per week, Fatigue in Men is not a noticeable factor.[57]

Vernon's view: Fatigue specially noticeable in the case of women.

Women's fatigue.

Men's fatigue in muscular work.

We are afraid that Dr. Vernon in spite of his great scientific industry is rather too hasty and dogmatic in his

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[56] Encyclopaedia of Industrial Hygiene, Vol. I, p. 1 (I.L.O.).

[57] Encyclopaedia of Industrial Hygiene, Vol. I (I.L.O.), pp. 15—17.

conclusions. There must be considerable error due to difficulty in assuring oneself that the same men were under observation for the whole statistical period of two years, specially as Vernon is dealing with a very large number. Any variations in the constitution and nervous and physical equipment of the replacing and newly recruited men must affect the records of injuries appreciably. Again his conclusions derived from the observations at a single Shell factory under controlled conditions in War times and a national emergency, when there were a large number of inexperienced workers in the Government factories, can in no case be safely applied to hold good of all other industries. Then, after all, a Shell factory is not a typical industrial undertaking; and its labour conditions and atmospheric and other environment are somewhat peculiar and different from those found in humid or hardware and hot industries like the Steel Manufacture, Coal-mining, or Gold-mining industries. Besides the psychic factors on which Dr. Vernon has laid so much emphasis there are other factors mentioned by Vernon himself which may be more important in other industries. Therefore Vernon's conclusions, though based on excellent data and observation, require very substantial modifications. An analysis of 1016 Railway Workshops made in 1928, in Bombay Press, to ascertain whether Fatigue has any appreciable effect on accident causation gives the following Statistical distribution of Accidents :—

Criticism of Vernon's views.

An Indian Example of Hourly Accident frequency Analysis.

	Time of occurrence of accidents.									
	8-9	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	5-5 30
Number of Accidents.	75	164	177	127	Break	77	112	137	104	43

It will be seen from the figures and the Graph that the accidents were very low in the first hour. We regret that the comparative output figures are not available. The work begins quite at a good time when workers can come comfortably from their homes, in a good frame of mind without much hurrying up.

Conclusions : Accident variations.

The ' initial spurt ' leads quickly to an ' incitement ' and therefore with increasing output the accidents also increase in an increasing proportion, to more than double in the second hour. (*Vide* Graph p. 213).) In the third hour when workers are in the full ' swing ' they become more careless and over-confident, and accidents reach their zenith of frequency, to about $2\frac{1}{3}$ times as much as in the first hour. In the last or fourth hour of the Morning Spell, Accidents come down all of a sudden to about $1\frac{1}{2}$ only of the first hour figure, which may be due to workers, stopping work some time before and also because they have "calmed down" and have their mid-day meal to look forward to. Vernon's view gets some confirmation from this study.

Psychic factors.

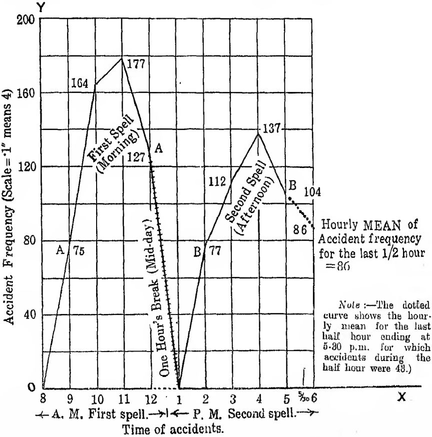
In both the Afternoon and Morning Spells, the two curves show identical tendencies in accident frequency. The good physiological and nervous effects of the mid-day meal are somewhat indicated by lesser number of accidents and much less increase in them in the second and third hour of the Afternoon Spell. The tendency towards the increase is qualitatively similar in both the accident curves. In the middle or third hour the accidents reach the highest point, and then fall down all of a sudden in the last hour and the last hour but one.

Evidence of fatigue.

The effect of Fatigue is clearly indicated in the third hours or the middle of the working period in both the morning and afternoon spells, and it is likely the output

also falls after this point relatively. The introduction of some suitable rest-pauses some time before this Fatigue point is reached, that is after two hours and a half is therefore likely to increase the output, and also reduce the Fatigue Factor and accident Frequency. It is unfortunate similar data are not available for other industries and provinces in India.

The statistical basis of this tabular classification requires examination, and these comments are subject to modification in case of Statistical Errors, if any.



Hourly Accident Distribution in the Railway Workshops in the Bombay Presidency.

Total Accidents = 1016 (Bombay Presidency).

(Based on the Bombay Govt. Factory Report figures for 1928-29.)

The Nature of Fatigue Products.

Production of Co2 is the most significant change during muscular contraction. "Fatigued muscle" is shown by litmus paper to be acid in reaction. A well-known experiment demonstrates the acidity of the fatigued muscle by the use of *acid puchsin*. This stain is injected under the skin of a frog, and absorbed and distributed in the body without injuring the tissues. "As long as the body remains at rest, the solution is colourless, but if one of the legs is electrically stimulated, the muscles take on a red colour, showing that an acid is produced locally."[58]

Chemical analysis of fatigue.

Mosso showed that the depressing effect of Fatigue was due to chemical reaction which was communicable to another organism. By injecting the blood of a fatigued dog to another dog at rest, he found in the other dog, signs of fatigue thus showing the chemical nature and toxic effects of Fatigue. Mosso measured these changes by the two instruments: the *Myograph* designed by Helmholz for measuring contractions of the muscles and the *Egrograph* designed by himself to measure the voluntary muscular contractions in man.

(*Mosso*: *Arch. fur Anatomie U. Physiologie Physiologische Artheilung*: 1890: p 90.)

Professor Lee finds "three distinct metabolic products in fatiguing—*viz.*, sarcolactric acid, monopotassium phosphate and carbon dioxide—all of which are acid in reaction."[59]

In 1904, Weichardt claimed to have 'isolated' a special toxin of fatigue like other bacterial toxins such as diphtheria on tetanus. "He asserts that if this toxin

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[58] Goldmark: *Ibid.*, p. 25.

[59] Harvey Lectures, 1905-06 by Lee (also *cf.* Popular Science) Monthly, 190, Feb., p. 182.

obtained from the extracts of fatigued muscles is injected into animals it produces all the symptoms of fatigue. When given in large doses, it is said even to cause death." He even claimed to have discovered an anti-toxin of fatigue found on administering small doses of toxin to animals.[60] "The fatigability of animals lessened and endurance capacity was said to increase under the influence of this anti-toxin."[61] But these theories "verging on the fantastic" have not been accepted by the scientific world so far—and they were uncorroborated at least till 1913. Even if true, this could not be of practical importance in an industrial regime, though it may have some value in endurance tests and bicycle races, etc. So far as we are concerned, these theories only illustrate and increase the gravity of our problem.

"Overstrain in industry is obviously no invention of sentiment or fiction when the chemical nature of fatigue and its complex relations with life are realised."

Fatigue Measurement.

As already observed, Fatigue is a definitely "chemical" product; and as such it can be subjected to chemical analysis. Some notable Italian physiologists specially Pieraccini and Gargioli have proved by laboratory experiments that a fatigued organism is a definitely poisoned organism—and the injection of the blood of a fatigued animal into the blood of a normal animal will produce fatigue toxins in the latter. In spite of this vague knowledge precise scientific results are difficult to obtain for the toxin called the Fatigue toxin has not yet been isolated and the claims of Weichardt in this respect are unfortunately not corroborated by the Scientific World.

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[60] Goldmark.

[61] *Ibid.* With full acknowledgment to Miss Goldmark, for various technical details regarding "Fatigue".

But even if the fatigue toxin were isolated, it would not help us very much in knowing the proportion of fatigue toxins in the human blood. The present scientific knowledge only helps us in ascertaining more or less precisely the nature of the chemical changes involved in 'exhaustion'; and the analytic properties of the "fatigue poison."

Importance of scientific study of fatigue in relation to industry.

But in ascertaining the amount of fatigue toxins in the human body—say of a labourer in a factory—Physiology does not take us very far, and the problem of "fatigue measurement" presents insuperable difficulties to the student of industrial psychology and labour economics. No study of labour welfare and the economics of labour can yield fruitful results without adequate attention to this important factor and we need no apology to discuss this interesting matter in some detail. The British Government realising the importance of this study specially instituted a permanent committee of eminent scientists and experts, called the Industrial Fatigue Research Board to investigate the effects of Fatigue on various industries.

As the physiological changes and psychic effects produced in human bodies during activity are almost incapable of exact measurement, industrial psychologists have thought it best to make output the *chief test* of fatigue. An optimum or normal product being assumed for a certain amount of a particular type of work in a certain period of time, we proceed to note the coming of fatigue with the falling index of output, other things remaining the same.

Methods of testing fatigue.

But the objection that other conditions do not remain the same and psychic changes are constantly going on in the subjects, vitiating our results, has to be ignored on account of practical difficulties. "The introspection of

the observed man is useful but it cannot be measured."[62] "We measure the activity itself and its product. We then measure the interval of time that elapses before the organism has gained enough activity to perform the same work in the same time with the same results."[63] A study like this is not possible in a short time—rest pauses are varied till the desired information is recorded in the date.

Gilbreth method of measuring fatigue.

"If two methods of doing the same piece of work take the same amount of time and produce the same amount of output and if the interval needed to recover from the second is longer than that needed to recover from the first, *then other things being equal*, the first method is more efficient."[64]

A careful study of the variables that affect the two methods show exactly why the first method is more efficient but the excess of fatigue in one, is a certain index that the other is more efficient. Fatigue according to this method is thus looked at in two ways:

1. As a product of doing work.
2. As a test of efficiency in doing work. From the purely economic point of view we are primarily concerned with the latter.

Activity as an instrument of efficiency is affected by the following factors:—

1. Amount of practice.
2. Extent of habituation.
3. Degree of interest in the work and the degree of the first momentum or start—which is an individual differentiation. But "most

[62] Gilbreth, F. B. and L. M., Fatigue Study, 1919; Routledge and Macmillan N. York, p. 116.

[63] *Ibid.*, pp. 115—18.

[64] *Ibid.*, pp. 115—20.

workers never get into the swing at the beginning of a work period."

4. Hour of the work-day and the time in the work-period.
5. The degree of "spurt"—when the work is being done at a rate above the normal pace.[65]

These factors in efficiency and industrial activity are also important factors in causing fatigue but it must be noted that the effect of all these factors on fatigue itself will depend on the relation between mental fatigue and bodily fatigue in most favourable circumstances.

Some mechanical methods to study motion and fatigue are given below. The description of instruments and their operation is based on Gilbreth. But Dr. Myers of National Physiological Laboratory of Great Britain has also given valuable hints in his valuable work on "Fatigue" and this book has also been consulted in preparing this description.

Methods of Motion Study.

Motion details of small units of activity and measuring the variables of these activities which are sub-divisions of the main-work involve "time study." "Time-study" and "motion-study" are thus closely related and almost inseparable.

Precise methods of recording motion.

A.—"*Micromotion Study.*" A concrete and precise method of recording motion and surrounding conditions has been invented by Gilbreth—and it is known as the Gilbreth System of Micromotion study. The recording is done by a Cinematograph and a special Gilbreth clock which registers extremely small intervals of time, smaller than the elapsed time between two pictures of a cinemato-

[65] Gilbreth: *op. cit.*

graph film—motions down to less than a ten-thousandth of a minute. This prevents errors in time-study and presents all the information correctly, eliminating errors due to "personal element."[66] It must however be noted that it is difficult to measure the orbit or exact path of the motions by the film.

B.—"*The Cyclograph Method*" enables us to record, measure and see this orbit or exact path of a motion or cycle of motions.[66] In this method, small electric lights are attached to hands or members engaged in activity and a photograph plate or film is then exposed while the motion is made, with the result that a path of light which resembles a white wire is seen upon the developed plate representing the path of the motion. The effect is best gained by a stereoscopic photograph which shows this path in three dimensions.

C.—*Chronocyclograph Method* enables us not only to see the *path* of motion but also its *directions* and the *duration* of the entire motion and of its elements.[67] "These chronocyclographs are made by attaching lights to the moving parts of the body on the machine as in cyclograph and by introducing a properly-timed *pulsating interrupter* in the circuit, adjusted not only to record the time and duration but also to record these with different graphs representing the path of each of the several motions made by various parts of the body and their exact distances, exact times, relative times, exact speeds, relative speeds and directions."

D.—*Penetrating Screen Recording*. Another method of motion measurement is by means of "penetrating Screen."[68]

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[66] Gilbreth: *op. cit.* With full acknowledgments to Gilbreth for these facts and this technical information.

[67] Gilbreth: *op. cit.*

[68] Gilbreth: *op. cit.* Gilbreth gives illustrations of these instruments in his book.

"It is possible to pass a cross-sectioned plane in any direction through any desired plane or through a number of planes in the cubic space under observation." This makes it possible to record the data with great accuracy in three dimensions and to read the information from the data easily. The various types of motion study may be employed according to the exact requirements. It must be understood that they are by no means to be considered exclusive or absolute in their applicability. These various methods "supplement rather than supplant each other."

V. HOURS AND REST-PAUSES IN INDUSTRY

Introductory remarks.

The idea of most employers at the beginning of the age of industrialism was to extract as long a period of work as possible at minimum cost, without much concern for the human needs of the working classes. It was this spirit of greedy commercialism which fired the righteous indignation of philanthropists and social thinkers like Carlyle and Ruskin who denounced the early economists and their imaginary postulation of that hideous creature "the economic man."

The literary renown of these noble writers who partially mis-understood the aims of Political Economy and the efforts of humanitarians and social workers, revolutionised the attitude of the public towards the underdog and emphatically inculcated the need of state interference in the interests of the society to ameliorate the lot of workers, specially women and children. The plea of laissez-faire gradually receded into the background and following in the wake of the successful policy of enlightened employers, the Government introduced with cautious steadiness various Factory Acts and workshops acts and subsidiary by-laws which enforced the hourly limits of work and respite and standard minima for ventilation, hygiene, temperature and other working conditions and Compensation Acts to atone for industrial hazards and diseases.

It is not our business in this chapter to recapitulate the provisions of the various factory acts which have done so much to improve the lot of the workers. It may be briefly mentioned in passing that much progress has been made in so many directions in great industrial countries like Great Britain and Germany and even in the United States. Still it is recognised by experts that even in

countries where a high standard in social legislation has been attained, a great deal remains to be done before workers may be considered to have a sufficiently human if not humane atmosphere for the operations of the day.

Welfare work and Industrial psychology.

The new department of welfare work is found in modern times to be a necessary adjunct to all big industrial undertakings in great industrial countries like England, Germany and the United States of America. Special departments of industrial psychology have been organised in Germany in particular to conduct scientific observations and researches into the best methods of work and ideal working conditions. It is not necessary for our purpose to explore the motives of welfare work—perhaps the " dollars and cents " and " it pays " ultimately—may be a more important factor in labour welfare activity than pure and simple philanthropy which is now resented by modern self-respecting workers. Whatever the motives, welfare work is certainly a most important factor in bringing defective working conditions to the knowledge of the management, and in inducing them to improve the social conditions inside and outside the factory.

Reduced hours and output.

In fact attention to minute details of working conditions has begun to be paid in England specially during the war—when the need for maximising national product led the Ministry of Munitions to make various elaborate experiments into the welfare conditions inside the munition factories. These experiments proved conclusively the desirability of restricting working hours and providing rest-pauses and more efficient lighting and ventilation and temperature inside the factories. Other great factories also have naturally been influenced by the example of the best employers and Government Munition Factories who have proved that provision of good conditions is economi-

cally profitable and paying ultimately, if not in the immediate future.

Before we discuss the question of Rest-pauses, and the results of experiments conducted at various factories, it is necessary for us to make some general observations. The necessity for restricting long hours is generally acknowledged and is borne out by the testimony of innumerable factories and laboratory experiments. Latest researches conducted by experts in various types of factories and varying climates prove conclusively the need of provision of suitable rest-pauses for getting the maximum output without unnecessary fatigue. In this connection, we cannot but draw upon the valuable information collected with such great industry and scientific precision by the Industrial Fatigue Research Board.

The desirability of Rest-pauses.

The pioneer work in providing lesser hours seems to have been done by the enlightened firm of Messrs Mather and Platt, Manchester, in 1893. Mather believed that "work before breakfast" .... "was economically as well as physiologically objectionable." So he began work at 8 A.M., instead of 6. In 1894, the Government Arsenals also adopted it on the instance of Mather; but the practice did not receive general acceptance, though Mather and Platt demonstrated it was a "paying" proposition. They also found that a 48 hours week instead of 54 for two consecutive years was economically profitable and was instrumental in increasing production and a decrease in lost time.

Pioneer experiments in shorter hours: Mather and Platt's lead.

In 1901, the Zeiss Optical Works. Jena, and in 1905 the Engis Chemical Works, Belgium, also proved from their experience that lesser hours of work resulted in increased output. The matter then became something more than a

Zeiss and Engis' profitable reduction of hours.

theoretical fad and it began to receive increasing attention.[1]

A great step towards the study of the subject was taken when a scientific body like the British Association decided to study "fatigue" from the "economic standpoint in 1913, for which purpose they formed a committee of inquiry. Another important stage came with the Health of Munition Workers' Committee formed in 1915 which after investigating records of the factories and carrying on experiments, demonstrated that "long hours" were "uneconomical" and "positively harmful" in certain processes and shortening hours increased production.[2]

British Association's study of fatigue and other committees' work.

In 1918 the most important step was taken when a medical research committee and the Department of Industrial and Scientific Research was established to conduct research on quite economic standpoint in 1813, for which factories. Professor C. S. Sherrington, F.R.S., was the President of this Committee. These bodies were appointed under the auspices of the Industrial Fatigue Research Board which has conducted such valuable scientific investigations.

Department of Industrial Research, etc.

Rest-Pauses and Shifts.

The effect of rest-pauses on production is clearly demonstrated from the results of various experiments and observations made by experts and scientists of the Industrial Fatigue Research Board. The effect of shorter shifts in increasing production is also proved.

Dr. Vernon conducted experiments in five factories employing tin-plate workers. "It was found when 4 hour

[1&2] Pigou: Economics of Welfare and Thomas Oliver: Occupations.

Effects of shorter shifts on the relative output of Tin-plate workers: Vernon's experiments.

shifts were worked for 10 months. hourly output during the last 7 months was 11·5 per cent more than when 8 hour shifts were worked. Observations on 6 hour shifts (lasting in one instance over 18 months consecutively) showed that the hourly output was about 10 per cent greater than for 8 hour shifts; but in that the working week is 2 hours less for 6 hours than 8 hour shifts, it follows that the total output is only 8·3 per cent greater."[3] "Millmen on 8 hour shifts, took *rest-pauses* on an average 12·5 minutes per hour, and millmen on 6 hour shifts took on an average rest-pauses 10·2 minutes per hour. Their hourly output was fairly steady—as it never varied more than 8 per cent from the mean."[4]

Dr. Vernon gives the main results of his experiments in Table 2 and Table 3 in his report No. I for the I.F.R.B.

8 hour shifts—hourly output and rest-pauses.

Hours of Shift.		RELATIVE HOURLY OUTPUT.					Total minutes per hour spent in rest-pauses.				
		Shifts.					Shifts.				
		A&E	F&F	C&G	D&H	Mean	A&E	B&F	C&G	D&H	Mean.
2 P. M. to 6 P. M.	I	95	118	94	104	103	13	15	12	5	11
	II	97	110	113	105	106	15	15	8	12	13
	III	94	84	88	116	96	15	19	18	5	14
	IV	93	101	105	99	99	15	13	9	18	14
10 A.M. to 2 P. M.	V	77	95	105	114	98	17	17	11	6	13
	VI	119	97	105	77	99	9	15	11	14	12
	VII	121	108	100	100	107	7	7	17	12	11
	VIII	105	87	90	84	92	10	9	21	11	13
Mean as 1/8 of total 8 hours output		100	100	100	100	100	12·6	13·7	13·4	10·4	12·5

[3] Vernon: Fatigue and Efficiency of the plate workers, p. 29.

[4] Vernon: Report I; I.F.R.B., London.

It must be noted however that rest-pauses were not absolutely true. Some departures were made in temporary reliefs; but some allowance for these has been made by Dr. Vernon.

N.B.—For this table and figures of output therein and also for the compilation of summaries of certain scientific conclusions the writer makes full acknowledgments to the Industrial Fatigue Research Board and its staff and also to His Majesty's Stationer Office.—*Author.*

Experimental results of Rest-pauses.

The laboratory experiments made by Wyatt and Fraser conclusively prove the beneficial effects on output of proper rest-pauses in most repetitive works. The Board consider that the evidence available "strongly suggests that the experimental introduction of rest-pauses at least for processes involving light repetitive work will have a successful issue." They continue "for this instance there is no reasonable doubt that in a working spell of 4 to 4½ hours the beneficial effects of a short rest-pause emerge through the many factors present in industrial work and cause genuine increase in output as well as greater comfort and satisfaction for the workers."

Wyatt and Fraser's experiments into rest-pauses.

According to the Industrial Fatigue Research Board, the evidence in favour of economic advantages of rest-pauses in "repetitive" work is "overwhelming." But the Board point out that the "response to a system of rest-pauses may often not be *immediate* and a period of some months may elapse before the full beneficial effect is apparent." The Board advise that "employers should persevere with the experiment for at least three months," and they emphasise that "*position, duration and even*

Are rest-pauses economically profitable?

[5] Report I, I.F.R. Board. Vernon: Tinplate workers—Table 2, p. 10.

the nature of the rest-pauses " are exceedingly important factors in determining the results obtained.[6]

Observation of 16 workers was undertaken in four factories over periods of 15 weeks by Wyatt and Fraser who made intensive investigations in order to allow corrections for other factors. The following results were tabulated[7]:—

Effect of rest-pauses on relative output.

1. An introduction of a rest of 15 minutes about the middle of the spell of work caused—

(*a*) An increase in the net rate of working which varied from 1·5 to 8·0 per cent—Hours of work, 8 A.M. to 1 P.M., and 2 P.M. to 6 P.M. except on Saturdays up to 5 P.M.

(*b*) With the exception of the afternoon spell in the stamping process an increase in total output was obtained.

(*c*) In handkerchief-folding, the actual increase was 2·3 per cent; in handkerchief-ironing 1·6 per cent and in the stamping-process (morning spell), 0·7 per cent. These are smaller than have been found in other instances.

2. In handkerchief-folding a slight modification in the conditions of work caused a reduction in the amount of lost time of over 50 per cent and an average increase in output of approximately 5 per cent.

3. The results in the three processes investigated are very consistent, and suggest that favourable results would be obtained by the introduction of *rests in most repetitive processes.*[8]

Again some laboratory experiments on 3 tried subjects —A, B and C—were conducted in placing bicycle-chain

[6&7] Report 32 "Studies in Repetitive work with special reference to rest-pauses" by S. Wyatt and J. K. Fraser, I.F.R.B., London.

[8] I.F.R.B. Report 32: By Wyatt and Fraser.

links on a pair of two steel shafts. In every case the output in the rest-pause series is generally higher than the un-interrupted series in the first 30 or 40 minutes immediately following the rest.[9]

Comparison of output in two series.[10]

Subject	Continuous series			Rest-pause series			Percentage increase		
	Halves		Average	Halves		Average	Halves		Average
	1st	2nd		1st	2nd		1st	2nd	
A	131·4	127·7	129·5	138·2	137·0	137·6	5·2	7·3	6·2
B	131·2	124·1	127·6	138·3	130·5	134·3	5·3	5·1	5·2
C	138·8	120·3	134·1	141·0	134·0	137·5	1·6	3·6	2·5

Then three spells of 50 minutes each with rest-pause of 5 minutes after each spell was tried on B. The superiority of the rest-pause work over the continuous series is again evident specially in the middle and latter parts of the spell.

Comparisons of output in Rest-pause and continuous series.[11]

	Part I	Part II	Part III	Average
Continuous series	140·1	126·9	127·8	131·6
Rest-pauses series	147·8	144·1	142·7	144·9
Percentage increase	5·5	13·6	11·7	10·1

E. E. Osborne has prepared a valuable report on "output of women workers in relation to hours of work in shell-making," 43 women were taken as subjects in shell-factory on "ripping" and "put off" operations, which shows similar results.

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9 *Ibid.*

N.B.—For these details and summaries the author makes full acknowledgments to I.F.R.B.

10&11 I.F.R.B. Report 32; p. 35.

N.B.—For these tables and summaries of results acknowledgments are made to I.F.R. Board and its investigators.

VI. HUMAN FACTOR IN INDUSTRY AND ACCIDENTS

The physical environment of the worker seems to have an appreciable influence on accident rate. Osborne and Vernon by installing recording thermographs at two large munition factories during the war were able to record the approximate temperatures at which the accidents recorded in the ambulance room were incurred during 10 to 12 months.

Temperature and accidents.

The results clearly suggested that there is an optimum temperature of 67·5 degree F. at which accident incidence is at a minimum. But the authors have pointed out that "the best temperature for accident prevention is not necessarily the most suitable one for working efficiency. There is little doubt that 67 degree F. is too high for the attainment of maximum efficiency if the work is at all active."

Optimum temperature for accidents.

Further *Vernon and Bedford's* study of the British Collieries confirms this effect of temperature on accident causation. As the temperature of the coal seam rose (or the Kata cooling powers fell) the accident frequencies of the colliers and trammers who work at or near the surface, tended to increase—while the accident frequencies of the haulage men and other workers, who work in the air ways where the temperatures are lower, remained practically constant throughout.[1]

These preliminary conclusions about the association of higher temperatures and increased accidents have again been confirmed by Vernon and Bedford regarding 23,000 miners' cause of absenteeism where the *accident frequency*

[1] Report 39, I.F.R.B., London.

was found *associated with temperature* specially *in "the less severe" types* of accidents.[2]

Another factor influencing accidents appear to be *air velocity*. The accidents incurred by underground men other than coal-face workers increased steadily at all velocities from 70 feet per minute upwards and at a velocity of 264 feet, they were 68 per cent more numerous.

Air-velocity and accidents.

Other factors influencing accidents.

Osborne and Vernon investigated the parts played by *Speed of Production* and *fatigue* respectively through the analysis of *50,000 accidents* incurred in the *Munition factories* working day and night. Variations in output during the period were measured simultaneously with variations in accident incidence. Their main conclusions are :—

Speed of production and accidents.

(*a*) "In the case of the day shift, a strong qualitative resemblance exists between the rate of output curves and the accident curves, thus suggesting that varying speed of production is responsible for the variations in accident incidence rather than fatigue."

(*b*) That fatigue may be an important contributing cause, however, is shown by the fact, that during a period when a 12 hour day (75 hours week) was being worked, the accidents incurred by women were $2\frac{1}{2}$ times more numerous than in the subsequent period when the daily hours were reduced to 10.

(*c*) "In addition to speed of production and fatigue an important part is played by psychical influences, such as alertness and attention. This conclusion is based on a comparison between the accident incidence on the day shift and on the night shift. Whereas in the former the accident curve follows the output curve, very closely, in

2. Report 51, I.F.R.B.

the latter it is widely different. There the accident rate is at a maximum at the beginning, then falls sharply and finally sinks to less than half the original value. Further, the total accident rate is lower by an average of 16 per cent with no decrease in output."

"The authors ascribe these differences to psychical influences assuming that the night workers started work in a careless and excited state, and gradually settled down to a calmer mental state than the day-workers."[3]

Psychological tests for Measuring Psychic factors.

Psychological tests have been devised for testing the intelligence and vocational aptitude of the workers, and there are innumerable methods or instruments for this purpose which all have a restricted value for a definite purpose. Attention and carefulness are elusive factors and not measurable for scientific purposes in a conclusive fashion. The following "Psychological tests" were devised by some scientific workers of the Industrial Fatigue Research Board to test and measure the alertness and carefulness of the workers and they are noted and described below as interesting illustrations :—

1. *The dotting test*—McDougal-Schuster Revolving dotting tests.
2. *The pursuit meter test*—to follow the irregular movements of a mechanically controlled pointer.
3. *The choice reaction test*—the subject was required to response to visual, auditory and tactual stimuli as rapidly as possible by placing his finger on the correct response button.

[3] Report 55, I.F.R.B., Preface, pp. V—VI.

4. *The interrupted pursuit meter test*—During the test-visual and auditory stimuli to which the subject was required to response, were given at irregular intervals. The visual stimuli were red and white discs and auditory stimuli were a bell and buzzer. Responses recorded by pressing button in one case and depressing his right or left foot in the other. The Score was automatically recorded as in previous cases.

5. *The co-ordination test*—by hand movements over green and white discs.

6. *The steadiness test*—To keep a stylus with a ball on the end inside a small metal cup without touching either the sides or the bottom, the cup meanwhile being automatically moved in an irregular way. Length of contact of the ball and cup was marked by a buzzer and recorded.

7. *The cube test*—to build a cube with 27 coloured bricks, each side being of different colour.

8. *The linguistic intelligence test.*

9. *The number-setting test*—get a certain combination of figures by moving certain set of levers.

10 *The stereoscopic test*—test card supplied by Messrs Zeiss—subject to place in their correct perspective certain pictures on the card as seen through a Zeiss stereoscope.

11. *The dynamometer test*—The subjects were required to grip a Salters' dynamometer with each hand in succession, the score being the sum of two grips measured in kilogrammes.

"Every test involves a group of psychological functions—for example in children intelligence seems to be the predominant factor which accounts for positive correlations of all tests with each other among children. With mental and physical developments, other tests take a more important part in test performances."[4]

Final Conclusions.

"The same reasons that account for the smallness of the intercorrelation coefficients are equally valid in respect to correlations between the tests and objective criteria of industrial proficiency and accident rate. The small correlations between the tests and objective criteria serve to indicate that industrial proficiency and accident proneness are dependent on many dominant factors and not upon one predominant factor. Even when the tests are weighed, they fail to give correlations of sufficient magnitude to warrant the assumption that they measure more than a portion of the factors involved in the objective criteria. It is clear that they measure some of the dominant factors, but there is no evidence that they measure the most important of them." Further experiment is necessary.

Practical application of these *tests to industry.*

"There is evidence that even at the present stage the use of certain of the tests described in addition to the existing examination, would result in the selection of entrants more capable of benefiting by instruction and less liable to incur accidents."[5]

Psychological study of individual differences in Accident Rates.

The variations in the internal susceptibility and proneness of workers are also important factors in accident

[4] Summary of the results of tests given by the I.F.R.B. Reports under reference. For the compilation of this summary by the Board full acknowledgments are due to I.F.R.B. & H.M. Stationery Office.

[5] Report 4, I.F.R.B.: Greenwood and Woods.

causation in many cases in addition to the psychic factors.

Individual differences in accident proneness.

The physical safeguarding of machinery and plant, however perfect, cannot reduce industrial accidents below a certain limit. Many accidents are due no doubt to pure chance and thus unavoidable in a strict sense, while others are in more or less degree due to personal characteristics of the victim himself.

As already stated, "Carelessness and ignorance" are very inadequate terms for description. The real questions are:—

(*a*) Investigation into "*individual susceptibility*."

(*b*) In what measurable respects do such individuals differ from their fellows?

Answers to these difficult questions are given by—

1. Greenwood and Woods[5]: in "*The Incidence of Industrial Accidents upon individuals with special reference to multiple accidents*"—This study is based on records at the Munition factories during the war, and

2. Newbold[6]: in "*A contribution to the study of the human factor in the causation of Accidents.*" This study of Newbold is based on more extensive data specially provided by 13 large factories in Great Britain.

These two studies have clearly shown that the observed distribution of accidents is far different from what may be expected from "pure chance," but is consistent with the idea that certain persons are temperamentally more susceptible to accidents. "These specially susceptible individuals constitute a

Special susceptibility of certain workers to accidents.

[6] Report 34, I.F.R.B.: *Vide* Summary in the preface of the Report by Chambers and Farmer: I.F.R.B.

comparatively small group and influence preponderantly the average of accidents in any homogeneous group."

Chambers and Farmer applied certain psychological tests to a large number of workers in different occupations and compared the results of the tests with their accident records. Though very confident conclusions cannot be drawn, due to the fact that additional data remain to be collected, the Board consider the results as "distinctly encouraging" and as "yielding positive indications."[7]

Experiments on special susceptibility.

Exposure to risk varies with different individuals. Hence "varying susceptibility" cannot *ipso facto* be inferred as the cause of differences. "*Accident Proneness*" is a narrower term than "*accident liability*" and means "a personal idiosyncrasy predisposing the individual who possesses it to a relatively high accident rate." "*Accident Proneness*" refers to "the possession of those qualities which have been found from independent research to lead to an undue number of accidents."[8] "Thus a person may be said to be accident prone without any knowledge of the number of accidents he has sustained for this statement will merely mean that he is more likely than others in equal conditions of exposure to sustain accidents. Such a knowledge would enable us to warn such people against entering certain special dangerous trades."

A Psychological test for measuring Accident proneness.

651 subjects tested—*i.e.*, 611 boy apprentices, 40 women factory workers.

Tests fall into 3 groups.[9]

[7] Chambers and Farmer: I.F.R.B. Report.

[8] *Ibid.*: For this Summary of experimental results full acknowledgment is made to I.F.R.B. and H.M. Stationery Office.

[9] I.F.R.B. Report—Chambers and Farmer: *Ibid.*

GROUP I

" Aestheto-kinetic co-ordination " tests*	(a) *Dotting test.* (b) *Reaction time test.* (c) *Pursuit meter test.*

These tests measure the afferent nervous impulses received through some specific sense organ, in the muscular performance of the hand, arm, or other parts of the body.

* *N.B.*—This term was used to distinguish from " Sensori-motor " and " Neuro-muscular" which have different scientific meanings.

GROUP II

1. *Tests of ocular balance.*

2. *Tests of Tremor.*

3. *Psycho-galvanic reflex tests.*

" These tests have all been shown to have a direct relation to *temperamental instability*, an important cause of accident liability. " Temperamental " includes " neurological " and " psychological " instability.

Tests for " Temperamental Instability."

GROUP III

1. *An intelligence test.*

2. *The number-setting test.*

These are Reasoning tests—for rapid and accurate thought.

Final conclusions from the tests.

1. Relationship between major and minor accidents definitely proved for same individuals establishes " individual proneness " to be a definite causal factor.

2. The investigation clearly shows "that the distribution of accidents is *in some degree* determined by personal *measurable* qualities."[10]

3. Many changes are detrimental to output because of their interference with the swing of work.

In addition there is a certain amount of evidence to show that:—

4. In repetitive work of a fatiguing nature, changes in the form of activity, should be relatively more frequent.

5. A high degree of resemblance between the alternating forms of activity, although subjectively satisfying, is not conducive to increased output.[11]

Variety and Uniformity in Work.

The general results disclosed by previous investigations on the effect of changes in activity and rest-pauses and variety in work is summarised as follows by a Report of the Industrial Fatigue Research Board:—

1. "A change in activity is beneficial only when the substituted task is easier than the operation it replaces."

2. "The superiority observed under the varied conditions of work is most marked when the

[10] Chambers and Farmer: *Ibid.*, I.F.R.B. Report.

N.B.—In dealing with highly technical psychological points and summary of experimental results of the scientific workers of the I.F.R. Board in this Chapter elsewhere the author has been compelled to follow too closely the expressions of the scientific conclusions of the learned investigators, in order to preserve technical precision of the subject. For these results and summaries and conclusions of experiments fullest acknowledgments are made to the I.F.R. Board and His Majesty's Stationery Office.—*Author.*

[11] Wyatt and Fraser: Variety and Uniformity in Work: Report 52, I.F.R.B. and Report 26, I.F.R.B., p. 13.

substituted activity is widely different from the one it replaces."[12]

3. "Frequent changes in the form of activity are detrimental to output, and long periods of unvaried work are equally unfavourable."

4. "Organised change periods are preferable to irregular interruptions throughout the day."[13]

It therefore seems abundantly clear from the various experimental investigation of the Industrial Fatigue Research Board that uniformity in methods and processes in any work is less productive than the introduction of variety in various processes. It has also been proved from one investigation that the "highest output is obtained" when "the form of activity is changed after 1½ and 2 hours of unvaried work."

Eye-strain in very fine processes.

The value of glasses in very fine processes is indisputable. They increase the output and also save workers from physiological injury due to serious "eye-strain."

Effect of "glasses" on output in fine processes.

Objectively very definite evidence of the value of the glasses is provided by a Report of investigations by Industrial Fatigue Research Board whose conclusions are summarised below :—

1. Rates of output substantially increased when the workers were supplied with glasses. "The amount of this increase varies in individual cases from about 8 to 26 per cent, for drawing in and from less than one per cent in an exceptional case to nearly 20 per cent for filament

[12] Thorndike: Educational Psychology, Vol. III, p. 135 (Columbia University).

[13] Journal of International Institute of Industrial Psychology: Vol. I/6, p. 236.

sorting and mounting." These figures refer only to experienced workers and still greater increase may be expected in the case of beginners.

2. "The average increase in outpnt works out at about 12 per cent."[14]

3. The loss of efficiency of those engaged on fine work due to accommodative *asthenopia*, or to the defensive "rests" taken to avoid or limit this form of eye-strain is exaggerated, as would be expected by errors of refraction and inferior visual *acuity*.

Optimum load for women in industries.

Employment of women in heavy industries.

With regard to the employment of women in the collieries underground or on the surface and in other industries in which manual labour and physical strength plays an important part, there are very important considerations of health and physiological injury which must be fully explored by scientific students in the broad interests of a country. The International Labour Conferences as well as the various nations are already doing their best to gradually abolish the employment of women underground in the Collieries. But the employment of women in heavy industries seems altogether undesirable, as it is likely to injure their delicate physiological stamina and may interfere with their powers of fecundity in some cases. In any case the carrying of heavy loads in heavy industries by young women workers is a matter of serious importance from the national standpoint. When we remember the large number of *coolie women* in various Indian industries, the importance of determining an optimum load and national legislation to prescribe the maximum load for coolie women becomes obvious. In India such questions are

[14] "Relief of Eye-strain in very fine processes": I.F.R.B. Report.

generally ridiculed by the employers and even responsible public women; but in western countries the value of the individual worker and his importance to the nation are fully recognised in practice by the Governments concerned.

For instance the British Government and its Home Office entrusted the duty of determining the optimum load for women to the Industrial Fatigue Research Board, and very valuable investigations with greatest scientific precision have been made by eminent investigators like *Prof. Cathcart, F.R.S.*, Beadle and others, who examined 4,000 women engaged in industries, with reference to (*i*) Weight; (*ii*) Height; (*iii*) Length of arm, distance of finger-tips from the ground; and (*iv*) Three physical strength tests—two requiring the use of muscles employed in industrial practice, and one requiring the use of muscles rarely employed.

Investigation to determine optimum load.

Cathcart's conclusions on optimum load for women.

The Chief conclusions deduced from the investigations of Cathcart and others[15] are summarised as follows :—

1. The strong women gravitate towards more strenuous occupations and it is also proved that the exercise of strength depends on mental alertness as well as physical capacity.

2. In the determination of the "*physiologically economic load*" the best rough physical indication of strength is *body weight*.

3. Practical conclusion is deduced that the variations in the strength of individuals can be met by assessing the economic load to be carried and lifted as a definite fraction of the body weight.

4. "The tentative conclusion is reached that *50 lbs. for "conveniently disposed"* loads and *40 lbs. for "incon-*

[15] "Physique of Women in Industry": Cathcart and others, I.F.R.B. Report No. 44.

veniently disposed " loads is about the *maximum physiologically economic load* for *women* continually engaged in carrying "[16]

5. According to laboratory researches of the "*physiological cost of carrying*," the most *economic load* appears to be *about 35 per cent of the body weight*, though the actual percentage will depend on the mode of carriage.

There is however the difficulty caused by the first conclusion above that generally women of special strength and capacity take to more strenuous occupations. Hence after considering the *anthropometric data*, two sets of conclusions are arrived; those applicable to the average of the subjects examined and to ordinary women engaged in industries not open to the selective influences; and those applicable to adolescent girls.

Final conclusions.

The following conclusions are finally deduced by the learned investigators :—

1. Maximum loads should be *40 per cent of the body weight for continuous* and *50 per cent for intermittent* carrying; which approximate to *45 and 55 lbs.* according to the average of the data examined.

2. Optimum load for continuous carriage by the average healthy women is 45 lbs.; though 50 lbs. will not be fatiguing in such a case; with a possible increase of 20 per cent if the load is compact and easily handled.

3. In the case of adolescent girls the risk of *malformation and distortion* of the body is very great; and therefore the investigators have prescribed an alternative limit of *25 to 30 lbs.* for female young persons 14—16 and a limit of *40 lbs.* for female young persons 16—18 years of age.

We have given such detailed description of some of these Experimental investigations by the Industrial

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[16] *Ibid.*

Fatigue Research Board, to show the national importance attached to these matters in western countries, where things affecting the vital interests and health and safety of the workers who are the producers of the national wealth are not left to the idiosyncrasies of indvidual employers.

The object of giving such experimental details.

Even in times of a national Emergency like the Great War, health and safety of the workers were receiving adequate attention. In fact the Ministry of Munitions in Great Britain was responsible for initiating most important investigations into the physiological requirements of the workers, and the Industrial Fatigue Research Board and Medical Research Council were especially organised on a permanent basis due to the demands of War industries for evolving measures to preserve the safety and health of the workers. Most of these experiments have been made by scientists of international fame who have made these investigations after intensive observation and detailed inquiries for years on end. In fact the scientific work and Research into the questions of health, safety and physiological requirements and optimum conditions of temperature, humidity, and air-velocity, etc., conducted by these standing Government Boards and committees in England, is unsurpassed by any other country.

England's example: her achievement on war time.

It is unfortunate that despite the remarkable progress in modern industrialism in India and her rapidly growing industrialisation, sufficient attention has not been paid to the growing requirements of suitable labour legislation. The Government of India of course have tried to keep pace with the important recommendations of the I.L.O. and the League of Nations. But this alone is not adequate to meet the demands of the situation. The public apathy in the matter safe-

Indian apathy towards labour problems. Government's neglect of labour research.

guarding the interests of the average worker is reflected in the indifference of the Government towards Labour Legislation, and in taking a keen practical interest in labour welfare. The modest recommendations of the *Royal Commission on Labour in India* have also been mostly shelved due to reasons of alleged financial stringency. The Government of India does not maintain any Labour Exchanges, any standing body like the British Medical Research Council or any important Research Committee to study labour welfare questions, and there is of course no question so far of having such Legislation as the Old Age Pensions Act, Housing Act or National Insurance Act, either in the mind of public men or the Government of India. The appalling illiteracy and hopeless disorganisation of Indian Labour leave little hope for much future progress. There is hardly any labour electorate for election to the Legislatures and there are only some Government nominated representatives in the Central Legislature. The Government is not so much to blame for these obvious deficiencies, for the public mind and social conscience have hardly been aroused to the great importance of social legislation for prescribing national minimum standards for various requirements of the workers.

Provision of Labour Welfare: a paying proposition.

The whole trend of this thesis based on the experimental results of eminent industrialists and scientists has been to the effect that, generally speaking, any improvement in the physical environment of the workers and atmospheric and internal conditions of a factory or anything done to improve the comfort of the worker while at work, is in most cases found to be a paying proposition as it results in increased output which more than compensates for the cost involved.[17] This has been

[17] *Vide* article "Welfare Work in Industry," Chap. VII.

the experience of most industrialists themselves as well as independent scientific investigators who have studied the question on behalf of British and other Governments. The employers therefore should do their very best to improve the conditions of work; as bad environment is ultimately a drain on industrial earnings.

Government of India Bereau of Industrial Research and Intelligence: a misnomer.

The Government of India made a good beginning by appointing the BUREAU OF INDUSTRIAL RESEARCH & INTELLIGENCE in 1934-35; and it was hoped that this Bureau will undertake some useful investigations into the conditions of Labour Welfare. But the object and programme of the Bureau have been altogether misconceived, which does not have a single eminent physiologist, or expert in Industrial and Labour Economics on its personnel to study labour and industrial questions and conduct industrial researches of all-India importance. It is hardly more than an extension of the Alipore Test House, to test samples of products of various industries. It seems designed to help the marketing of the products or for similar purposes or to give some technical advice, if at all, about the quality or contents of various articles. In this sense, the name "Bureau of Industrial Research" is hardly justified and about its "intelligence" service also grave doubts must be expressed, for there is no Statistician with specialisation into industrial and labour questions on its staff who can competently handle or prepare reliable industrial information and statistical statements about the Indian Industries.

What the Bureau should have done? Its proper personnel.

The name had raised hopes in the mind of technical students, that the Bureau will be a sort of standing Committee more or less on the lines of the Industrial Fatigue Research Board, or at least undertake in part work of that description, which is desirable urgently in

national interests, by having some eminent industrial economists, Labour Statisticians and Industrial Psychologists on its staff. It is therefore most regrettable that the Government have not constituted this Bureau true to its designation, according to the personnel of such bureaux and Boards in England and elsewhere; and it is seriously doubted that the bureau in such circumstances can do any work of much value to industries or in the best interests of the Indian workers. It is urged that the Government of India may soon take proper steps in this respect by levying some tax on the industries, if necessary, for doing useful and imperative work of this type which, though of value to all industries and workers' organisations, cannot be undertaken by any industries or firms singly in their individual capacity. The cost of a standing Board of Industrial Research under Government for investigating matters of vital interest to the health and safety of the workers which is of emergent national importance must be contributed according to the capacity of each industry by the whole group of industries as well as the Central Government.

Dangerous trades and accidents.

In the dangerous trades specially attention to the safety and Health of the Workers are very great. The Indian Factories Act specifies various safeguards, and fences, etc., and other compulsory devices to ensure the safety of workers' lives and minimise accidents, and the Indian Mines Act also has a similar set of provisions. But these simply are not enough. In each particular industry the dangers and risks must be studied carefully by the management with the co-operation of the Workers.

With this view "Works Councils" have been commonly instituted in various countries with representatives of employers as well as employees to study the points of conflict between the parties and to investigate matters

which affect workers' comfort and safety. A successful "Works Council" makes also for smooth relations between the labourers and employers, and improves production by ensuring the contentment of the workers. In Indian industries such Committees and Councils are few; and successful ones are much fewer, with the result that there are recurring labour disputes. Elaborate 'Safety First' propaganda is carried on by Governments and bodies of employers in various countries in Western countries like England, Belgium and Germany and the United States in order to improve safeguards on machinery and provide adequate fencings and other protective measures in order to minimise accidents which require a heavy cost in compensation in countries where wages are appreciably high as in the west. In India and Eastern countries accidents receive so scant attention mainly because many industries consider that the cost of compensation for injuries and accidents is not so very great for them to bear; and some of them veer round to the callous view that to provide these additional safeguards and special Safety measures is more costly on an annual basis than the actual cost of annual compensation in their factories. This seems hardly a correct estimate, for with the worker whose compensation is calculated on the "wage" basis, his skill and experience also is lost. This requires the cost or loss due to the additional training, and additional turnover. To take a leading example, the Tata Iron & Steel Works, Jamshedpur, paid about Rs. 44,000 in compensation for 26 partial, 22 permanent and 21 fatal accidents in 1928, and this is not such an insignificant annual amount, even for large works of the size of Tatas. In smaller industries the recurring cost of compensation and loss of skill and increased turnover must be proportionately much greater and a serious drain on the income of the industry.

"Works Councils" and "Safety First" propangada.

In Europe and America the relation of accidents to the human factors is fully realised by industries as well as the public. The ensuring of the ease and comfort of the worker is a sure incentive to better production and smoother relations, and means to afford such ease and comfort are adopted in the interests of output and not from any philanthropic motive. For instance the Ford Factories in Canada employ hundreds of safety devices and almost every safeguard has been adopted by the Ford Engineers. The piling of stocks, lighting and cleanliness are ideal and the movement of workers is reduced to minimum by mechanical automatic supply of materials and tools to each worker at his place. Everything in fact has been done to reduce fatigue and useless effort and lessen accidents.[18]

Ford Shops: Safety Devices and effect on output.

The question of Safety Devices is an Engineering problem as well, and the safeguards some of which are built integral with machinery must vary with the innumerable type of machines in industrial use; and there is no place for engineering details in this study, which must be reserved for separate treatment. But the question of Safety-First and Accident Prevention has now assumed international importance, and non-official national Safety-First associations have grown up in important industrial countries of Europe and America to do propaganda work for ensuring safety of the workers. The *British Safety First Association* has done a lot of useful work of this type and the Factory Inspectorate is in close touch with it. The co-operation of the employers and employees is indispensable for accident prevention. Bold Safety Bulletins in Vernacular and illustrations of points of hazard in prominent colours are most useful and Indian industries are

The benefits from "Safety" organisation.

[18] Arnold and Faurote: **Ford Methods and Shops**, pp. 418—22.

not quite alive to their importance. Dangerous parts of the machinery should according to *Dr. Brisco* be coloured in bright red to call pointed attention to them, and this is a safe and inexpensive suggestion. As according to *Dr. Vernon*, about 90 per cent of the causes of industrial accidents are attributable to some sort of negligence or carelessness on the part of the worker,[19] an active realisation of the danger by the prospective victim is the first necessity in bringing some reduction in preventable injuries.

U. S. National Safety Code for protection of the head and eyes.

We cannot do better than advert to the Safety Devices mentioned in the National Safety Code prepared by the United States Bureau of Standards for the protection of the Heads and Eyes of the Workers (most important parts from the point of view of accidents) which is the result of detailed investigations of 20 experts.[20] The number of industrial operations injurious or dangerous to heads and eyes are extremely large and they are *classified* by this Code mainly as (*i*) *protection against large flying objects, e.g.*, chipping and some riveting operations; (*ii*) *protection from dusts and small flying particles;* and from winds, *splashing material* like lead joints and casting hot metals; (*iii*) *protection from fumes and gases and liquids;* (*iv*) *protection from excessive amount of reflected light;* glare and injurious radiant energy; and (*v*) *protection from injurious radiant energy and visible radiant energy* beyond moderate degree. The Code after classifying the various risky processes defines the *different classes of appliances to protect the head and eyes:*—(*i*) *Goggles* of three types—with a flexible frame;

[19] Dr. H. M. Vernon: I.L.R., May, 1926.

[20] United States Department of Commerce—Bureau of Standards—National Safety Code for the protection of Head and Eyes: 1923, p. 66.

with rigid adjustable or non-adjustable bridge to suit various processes; (*ii*) *Face masks* protecting the eyes and all parts of the face; (*iii*) *Helmets* to cover eyes, face and other parts of the head; (*iv*) *Hoods*, completely covering the head, neck and part of shoulders; and (*v*) *Shields*, held in the hand or forming part of the machine beside gas masks over nose, etc., to protect these delicate parts against industrial dangers.

Industrial diseases and hazards.

Apart from these protective measures and safety devices, provision has to be made against the increase of *sources which lead to various industrial diseases and occupational internal risks* in hazardous industries. These occupational diseases are also in the purview of the Workmen's Compensation Acts in the various western countries and there is an increasing tendency to comprehend these purely "industrial diseases" and hazards under the term "Accidents."

Importance of the human factor.

The worker is a man first and last, and he responds with his whole being to the stimuli of light, beauty, cleanliness and order. Therefore any attention paid by the management to increase his mental satisfaction and improve his environment and comfort during work is, generally speaking, sure to bring out better reaction from the worker's side unconsciously and must in general result in increasing the relative output, after making due allowance to satisfactory adjustments. Any such ameliorative measures making for better working environment and a healthful atmosphere must also add to the worker's efficiency and indirectly if not directly lead to a *reduction in the rate of accident frequency*. It is wrong to look at the worker purely from a mechanical standpoint or from the point of the "cash nexus," which is not only unnatural but must lead to increased friction. As Dr. Drever has pointed out the

urge to industrial activity springs from deep " spiritual " impulses which affect the whole being of the worker; and it is injurious to all concerned to ignore these intimate sources of industrial endeavour.[21]

[21] J. Drever: Human factor in industrial relations ("In Industrial Psychology," edited by C. S. Myers, H.U.L., pp. 17—19).

VII. WELFARE WORK IN INDUSTRIES*

Definition of Welfare Work.

Large factories in Europe and America have, during the last twenty years, paid increasing attention to 'welfare work,' which has brought about a great improvement in labour conditions. Welfare Work or what is sometimes called 'Social Betterment' and 'Model employment'[1] consists of '*voluntary* efforts on the part of employers to improve *within the existing industrial system* the conditions of employment in their factories.'[2] It does not, in this narrow technical sense, postulate any fundamental change in the capitalistic basis of industrial organisation; but it certainly implies a new attitude on the part of the management and a new social responsibility.

Industrial experiments during the Great War.

During the Great War, a great impetus was given to Welfare Work in Great Britain. In view of the great national emergency, the Government did everything possible to stimulate production. Experiments in Welfare work were made on a vast scale in the Munition factories;[3] and controlled undertakings and measures taken to improve the environment and comfort of the workers were in most cases economically justified, resulting in a great increase in output.

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* For this Chapter full acknowledgments are due to Mrs. A. E. Adair, Editor, The Ananda, Madras. The Article appearing in that Magazine under the title "Humanising Indian Industry" forms the present chapter.—*Author.*

1 Macgregor: Evolution of Industry.

2 Proud: Welfare Work.

3 Hutton: Welfare and Housing.

The growth of Welfare work is *partly* due to a new spirit of 'moral industrialism' which has come to recognise that the 'cash nexus' is not the sole basis of relationship between employers and employees.[4] But it may be admitted, that . . . 'business is business,' and in industry purely 'economic' factors are more powerful than sentiments. Economic motives, hope of increased production per capita and of increasing profits in the long run are therefore, in most cases, the preponderating considerations in Welfare work. It would, however, be rash to suggest that no humanitarian feelings are involved, since man's actions result from very complex motives; and many of the great leaders of industry who pioneered 'welfare work' have been men of broad social sympathies.

Motives for welfare work.

The worker is not a mere 'hand,' but a human being first and last. He is a sensitive creature, whose productive energy is affected by his environment and his psychic reactions to the stimuli of light, air and beauty, and of temperature and humidity inside the works. The new Science of Industrial Psychology has demonstrated that these are important factors in determining the worker's efficiency. We can thus conceive of an optimum standard of these requirements which industries must strive to reach in order to yield the greatest contribution to the National Dividend. One must agree with Professor Pigou's[5] suggestion that the State must fix the minima of each of such requirements in the interests of Society; and no factories must be permitted to bring in degraded conditions.

Human factor in industry.

In America, a new "Efficiency movement" has been

[4] John Lee: Principles of Industrial Welfare.

[5] Pigou: Lectures on Housing, Manchester University.

started to emphasise the importance of 'Model Employment' in a purely economic spirit. To Brisco,[6] it is a mere 'dollars-and-cents proposition' as it improves productivity and the relations between capital and labour. But, whatever the motive, it is a fact that Trade Unions resent welfare work as a 'dole,' and 'insidious philanthropy,' which will impair their class solidarity and damp their fighting zeal, and may even prejudicially affect wages. The new worker wants good conditions as a right and therefore wise industrialists do not expect gratitude for betterment measures. It would, perhaps, show a better moral sense if there is less trumpeting of the philanthropic motive; and it would certainly lessen the suspicion of the workers, whose sense of self-respect and independence will not be undermined by accepting 'charity.'

"Efficiency Movement" in America.

In India, factory labour is not well-organised, and the Indian worker is not even half as self-reliant or aggressive as his western brother. Patronage is highly valued in Indian Society, and the Indian labourer, helpless on account of his abysmal ignorance, looks upon any concession from employers with a 'mai-bap' feeling which is often demoralising. With greater organisation, mass education and filtering in of the western proletariat feeling he is becoming more self-reliant and restive. When screwed up, during periods of conflict by outside agitators, he ceases to be the meek creature that he was; and therefore Indian big employers are seriously considering the introduction of welfare arrangements to placate the labourers and lessen the recurring troubles. Bad environment and neglect of labour welfare may be one of the important causes of incessant strikes in India.

6 Brisco: **Economics of Efficiency.**

The prospects of welfare work can only be increased by a demonstration of its economic feasibility.[7] I give here the results of certain industrial investigations. According to Professors Urwick and Brisco, normal capacity has been found to increase by 17 to 20 per cent from changing bad lighting arrangements to well lighted conditions. Good lighting is therefore an essential condition of efficient work. Bad ventilation increases fatigue and brain-fog. In India, ventilation is seldom sufficient; and illiterate workers and 'inefficient' employers alike care little for it. One of the most remarkable features of the Ford workshops is the 'Hollow-Column Air Circulation System,'[8] which avoids air-pipes, by making all inside floor-supporting columns hollow, with openings near the ceiling, to regulate air supply through 'air-conditioning units.' Some big Indian factories should consider its adoption.

Economic justification for welfare work.

Attention must be paid to every detail. Experts say that air in a factory should move 2 to 5 ft. per minute. In Illinois, U.S.A., the law provides for 1,800 cubic feet of air per hour for each person in a factory. The window and door space must be $\frac{1}{8}$ of the floor area. The space allowance per person should be at least 250 cubic feet in daylight and 400 cubic feet in the dark.[9] These are considered roughly as good minima by experts. In India, the Factory Act does not provide for such minima to ensure the safety of the employees; and

Some standard minima for social and industrial conditions.

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[7] Brisco: Economics of Efficiency.

[8] Arnold and Faurote: Ford Methods and Ford Shops.

[9] *Cf.* Watkins: Labour Problems; and H. L. Srivastava, "Economics of Industrial Accidents" (M. S.—Economics Department, Allahabad University) for detailed information.

much is left to the careless fancy of an overbusy factory inspector. In India, also, factories are often very clumsily constructed and ill-adapted for the working of modern machinery, which leads to a large number of accidents. According to the Bombay Factory Report, for 1923, out of eighty-two fatal injuries, thirty deaths were reported as due to the 'collapses' caused by overloading the 'original end wall' with the new structure, during an extension in the Ahmedabad Mill; and, at another mill, 'the mishap' was due to the addition of a second storey.[10] No new machinery should be allowed to be installed in an old building without previous approval of the structure by the Factory Inspector; and drastic changes in the size of the plant should be controlled.

Optimum lighting, temperature and humidity.

Dr. Vernon[11] found in the munition factories that, on an average, the night accidents were 17 per cent more than the day accidents. Hence proper lighting regulations are very important. In a tropical country like India, suitable temperature requires first attention. Dr. Haldane observed that 80° F. with moderate humidity and 70° F. with high humidity caused depression, dizziness and headache; and such are the ranges of temperature in many Indian factories in summer. The 'best working temperature' was found to be 65° to 70° F., with an average humidity of 60 to 70 per cent. This is borne out also by the experiments of Drs. Vernon and Osborne[12] at two large shell and fuse factories during the War after almost twelve months' study. They found the *least* number of accidents occurred at a temperature of 65° to 69° F.

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10 Bombay: Report, Chief Inspector of Factories, 1923.

11 International Labour Review, Vol. XIII, V, p. 681.

12 I.L.R., Vol. XIII, V; Vernon: The Human Factor in Industry.

In India little attention is paid to Welfare work, probably because labour is extraordinarily cheap. No betterment measures are undertaken to improve efficiency because men can be had to bring about increased production at cheaper price than the cost of welfare activity required to stimulate the expected increment in output. Dr. Gilbert Slater thought that the *chief* reason for employing proportionally more labourers for the same task in the Buckingham and Carnatic Mills as compared to Lancashire was, not so much the glaring 'inefficiency,' as the 'cheapness' of the Indian worker; and he dismissed Sir Clement Simpson's plea that the Lancashire Cotton worker was 2·67 times as efficient as the Indian as hardly more than an arithmetical quibble. This factor needs further investigation.[13]

Chief reason for neglect of welfare work in India.

Cooling and humidifying apparatus is urgently called for in Indian cotton mills in summer; and it could hardly prove more costly than heating the Lancashire Mills in the cold season. It is gratifying to learn that "Ahmedabad has recognised the need of efficient cooling and ventilating arrangements;" and that the Sholapur Mills have installed 'several special ventilating and humidifying plants' to 'neutralise the trying climatic conditions' at these centres.[14] The Government must make these measures compulsory at least in big Cotton Mills, as their economic practicability is almost established. At present, even Kata thermometer and hygrometer reading records are not compulsory in most provinces, and we cannot get an idea of actual temperature and humidity in the Cotton Mills.

Cooling and humidifying apparatus in Indian cotton mills.

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[13] Indian Industrial Commission Report.

[14] Bombay: Report, C. I. Factories, 1927.

"Overtime and Long Hours" generally unprofitable: Experimental results.

We now take up the much disputed question of Long Hours and Overtime, which appear to be positively injurious, beyond a certain point, in their effect on the total output, as was discovered by many British factories during the War. "After the first feverish rush it was found that, at least in two important districts (Leeds and Glasgow), employers refused to allow overtime, even though men were willing to work."[15] Many factories found it more economical to reduce the working hours. The experience of a crown factory is said to be that "any lengthening of the day beyond 6 p.m., and a total of 8½ hours' work daily exhausts the workers and is of no advantage in increasing output."[16] Another factory with 2,000 women and girls is quoted by the Factory Inspector as reducing the hours from 7 till 6 to 8 till 5 and 'output remained the same.'[17] "Experience in Europe and America has undoubtedly continued to show," says Professor E. J. Urwick, "that a reduction of the 12 hours day to 10 hours (8½ actual), or even less, is accompanied by a greater regularity of work and quicker production, with little or no diminution of total output. In many cases there has been an actual increase of production."[18] Professor Urwick substantiates his conclusion with important examples from experiments in America and Europe. "In 1917 the Ministry of Munitions reported a 10 per cent increase in production of men when hours were reduced from 10½ to 9½ actual."[19] "This firm

15 Proud: Welfare Work, p. 152.

16 Grt. Britain: Report, Chief Inspector of Factories, 1914.

17 *Ibid.*

18 Report by London Welfare Committee for the Tata Welfare Work Scheme and Papers by Prof. E. J. Urwick and Mr. and Mrs. Sydney Webb, etc. (not published).

19 *Ibid.*

have been working overtime continuously for several months," a firm is quoted as reporting, " but have found it *absolutely* necessary to stop it for a week as the strain was becoming too great and the number absent through illness was so large."[20] Professor Urwick cites the case of a tobacco factory where " an increase of 30 to 50 per cent in ailments among the work-people was discovered after a period of overtime working."[21] The necessity for proper rest-pauses cannot be overemphasised. In their absence 'surreptitious breaks' and 'lavatory loitering' are frequently resorted to by women; and " it only shows how great the strain is on women and girls that they should desire rest so obtained."[22] " With properly adjusted intervals for rest," says Proud, " it is less strain to produce the same quantity in a nine hour day than in a ten hour day."[23] During incessant work, without good rest intervals, muscles become rigid and less responsive to nerve stimuli, as the toxic impurities accumulated during continuous effort poison 'the nerve cells in the grey matter of the brain.'[24] The attention therefore flags; rhythm of movement is less regular; and there is an increase in the number of serious accidents which may require huge compensation cost. " The efficient cycle should be work to the period of sensation of fatigue and sufficient rest to repair the body of its losses."[25] '*Speeding up*,' the result of *Taylorism* or '*Scientific Management*,' overtime

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[20] Grt. Britain: Report, Chief Inspector of Factories, 1913.

[21] Report by London Welfare Committee for the Tata Welfare Work Scheme and Papers by Prof. E. J. Urwick and Mr. and Mrs. Sydney Webb, etc. (not published).

[22] Grt. Britain: Report, Chief Inspector of Factories, 1914.

[23] Proud: Welfare Work.

[24] Brisco: Economics of Efficiency.

[25] *Ibid.*

bonuses and piece-work are sure to bring exhaustion, especially in the case of ill-nourished workers in the enervating climate of India. Welfare departments must make a careful and scientific study of these questions which are of greatest significance to all businesses; and must adopt sound measures to reduce fatigue and avoidable ailments, resulting in absenteeism, misery and economic loss.

Welfare Work: Its scope.

Welfare Work generally includes the provision of all facilities which are conducive to the realisation of the workers' full physical, mental and moral efficiency. *During work* it includes the provision of optimum standards of ventilation, light, temperature, sanitation and hygiene; and the investigation of such general problems as hours of work, fatigue, half time, shifts, rest pauses, labour before and after maternity, provision of crèches for children during work hours, safety first measures, provision against hot floors, heat, glare, noise and dust, fumes[26] and dangerous gases; as well as meals during work hours, provision of rest rooms, shower baths and recreation during intervals, and first aid treatment in case of injuries. We are primarily concerned in this article with Welfare Work *inside the works;* but cannot touch more than a few items in our discussion. The shift system of work which obtains specially in the Jute mills is certain to cause a great and alarming disturbance of family life and is liable to great abuse on the part of employers and deception on the part of workers. It makes the observance of factory laws a difficult affair. It is being gradually abandoned by many

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[26] *Cf.* Watkins: Labour Problems; and H. L. Srivastava, "Economics of Industrial Accidents" (M.S., Economics Dept., Allahabad University) for detailed information.

of the Jute mills. Pre-natal and post-natal period requires stringent regulation in the case of woman labourers. Though there is a system of leave with pay instituted voluntarily by many important Indian factories, a definite law for the whole of India, providing for maternity benefits and humane treatment of such woman workers, is urgently called for in the interests of the future generation. Maternity cases naturally demand the close attention of Welfare workers. The question of 'safety' and prevention of industrial accidents requires greatest attention[27] in the Iron and Steel industries; and in chemical, painting, leather working and ceramic trades, occupational hazards and possibilities of industrial diseases[28] are most serious; and these technical matters form an important care of the welfare departments. *Outside the works* there is a vast field of 'betterment' activities which is beyond the province of this article to discuss in detail. The following list is adapted at random from *a Welfare Scheme recommended for the Tata Works by a Committee of Experts*[29]:—technical, adult and primary education, sanitation, housing, garden planning, boulevards, tree planting, rapid and cheap transit and communication, parks, baths, 'civic centres' and public halls; infection, prevention, ambulance, first aid and medical dispensaries, maternity clinics and benefits; domiciliary visits by health and social visitors, gymnasia, playgrounds, worship, social gatherings and clubs, 'bhajan' parties, circulating libraries, reading-rooms, hygiene and temperance campaigns, cinema shows, co-operative stores and credit, provision for workers' leisure and auxiliary trades.

[27] *Ibid.*

[28] *Ibid.*

[29] Report by London Welfare Committee for the Tata Welfare Work Scheme.

Some labour welfare schemes in India.

In India[30] the British India Corporation, Cawnpore, the Tata Steel Works at Jamshedpur and Bombay, the B. and C. Mills, Madras, and the Empress Mills, Nagpur, have Welfare Schemes; but considering the magnitude of the problem, they are hardly more than a good beginning. *The Buckingham and Carnatic Mills'*[31] report among their Welfare activities :—kindergarten classes in the 'model villages,' special technical classes with a free mid-day meal for working children, gratuity and savings funds, privilege leave, village halls and workmen's stores. *The Tata Steel Works* have institutes with concert and billiard halls for better-class workers, a technical school, the activated sludge system of sewage disposal, a dairy farm, and a rest-house for Coke Oven coolie women. Without going into details, I feel the conditions of the Coolie Town and the housing of low-paid employees require radical improvement. The social needs and welfare of the lower class of workers have not received adequate attention, in spite of the fine work done by Mr. Thakkar of the Servants of India Society. It is regrettable that the Tata Company have neglected a fine opportunity of 'garden-city' development, for which Tatanagar has very great prospects. Perhaps in the happier atmosphere of a garden city many of the recurring misunderstandings and conflicts would not have found a fruitful soil, for the Company appears to be paying much better wages than most places in India. The work done by the *British India Corporation*, under the fostering care of Mr. Mattison, deserves a word of praise. The *McRobertganj Settlements of the Corporation is probably the best housing scheme* of its kind in India.

30 Welfare Work Reports for B. and C. Mills, 1925-27 and the B. I. C.

31 *Ibid.*

A discussion of industrial welfare will be incomplete without some reference to the evils of bad housing in industrial centres in India. In other industrial countries serious efforts have been made to remedy these evils; and garden cities have been developed at *Port Sunlight*, at *Bourneville* and *Letchworth* in England, and at *Hellerau* near Dresden, for housing the workers in healthy suburbs connected with the works by rapid locomotion. They are proposing to build Dormitory towns for coal workers; and Housing and Town Planning Acts have been enacted to remedy the housing evils.

Garden cities and Town Planning to counteract evils of over-crowding.

Bad housing has serious effects on the health, efficiency and moral stamina of the workers. In India, the problem has received very little public attention. Let us take the most notorious case of Bombay, whose average density is over 78 persons per acre, while the density in its industrial areas is from 300 to 500 and at places even 700 persons per acre. The narrow, dingy and squalid chawls, in which workers are hopelessly clustered, rise often six stories high with a small gully between, in which the refuse of the privies flows freely. *Bombay is perhaps the most overcrowded city in the world.* London has only 6 per cent of her population in one-roomed tenements with an average density of 1·92 persons per room. Bombay has 66 per cent of her population living in one-room tenements with an average density of 4 persons per room.[32] Dr. Barnes, an official medical visitor, in the course of her Enquiry found a room 15 ft. × 12 ft. occupied by six families of over thirty persons, of whom three were women expecting delivery and for whom a space

Evils of congestion and bad housing: Bombay's notorious example.

[32] Census Report, 1921; and Broughton: Labour in Indian Industries.

3 ft. × 4 ft. had been screened off. The effects on health and morals of such overcrowding, wholly destructive of decency and family life, must be most serious.

Bombay's infant mortality: highest in the world.

The relation of housing conditions to infant mortality is very close indeed. 75 per cent of total births in Bombay occur in one-room tenements, which also shows the state of morality and continence in these overcrowded homes. The rate of infant mortality of the City is over 86 per cent, according to the Government Sanitation Commissioner, probably the highest in the world.[33] Is it not absurd and quixotic to expect improved efficiency and a contented labour force to emerge from these dirty hovels? There can be no end to strikes and class conflicts till these bestialising dens are demolished, and cheap and sanitary houses are provided for Bombay workers. It is a most serious reflection on the business capacity of the employers, as well as on the moral tone of the community, that such conditions are allowed to exist. Housing in industrial areas gives rise to far-reaching problems which must be carefully examined by students of social welfare.

Test of welfare work.

The actual extent of Welfare Work in any business must depend on the finances and future prospects of the industry, as well as on the efficiency and standard of life attained by the workers. But the real 'test of welfare work' has always been the advance made over the 'objective minimum fixed by legislation,'[34] which has followed with a cautious tardiness the example of industrial pioneers in 'social betterment.' When wages are sufficiently high and a standard of 'reasonable comfort' has been attained by

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[33] Census Report, 1921; and Broughton: Labour in Indian Industries.

[34] Proud: Welfare Work.

the workers, an investment in welfare work, which would increase their efficiency, is theoretically preferable to an increment in 'nominal wages' A *sudden* increase in money wages often leads, as Professor Pigou[35] has shown, to extravagance and vice among the working classes.

[35] Pigou: Economics of Welfare.

SECTION V

URDU

QAZI MAHMUD BAHRI AND HIS CONTEMPORARIES

BY

DR. M. H. SYED, M.A., PH.D., D.LITT.

I

The following books on the history of Bījāpūr and its conquest by Aurangzīb have been consulted:—

(1) *Qazāyā-i-Salāṭīn-i-Dakkan.*—A history of the *Dakkan* from the early Muslim conquest to 1743 A.D. By Mirzā Mahdī Khān, also known as Niẓāmuddīn Muḥammad Hādī. MS. India Office, p. 339.

(2) *Tanmīqī-i-Shigarf.*—A history of the *Dakkan* from the early Muslim conquest to 1786 A.D. By Lachmi Narāyan Shafīq Aurangābādī. MS. India Office, p. 1732.

(3) *Futūḥātī-'Ādil Shāhīs* from their origin to 1643 A.D. By Fuzūnī Astrābādī, commenced by the order of Muḥammad 'Ādil Shāh in 1640 and completed in 1643. British Museum Add. 27251.

(4) *Aḥvāl-i-Bādshāhān-ī-Bijāpūr.*—A collection of news and dates of the kings of Bījāpūr, by Mīr Ibrāhīm bin Mīr Ḥusain Asadkhānī. In the reign of 'Alī 'Ādil Shāh II. B. M. Add. 26296.

(5) *Vaqā'i'-i-Salāṭīn-Bījāpūr.*—A condensed form of Maḥmūd Nāma, to which the author has added more events down to the time of Sulṭān Sikandar. By Shaikh 'Abdū'l Ḥasan bin Qāẓī 'Abdu'l 'Azīz bin Qāẓī Tāj Muḥammad, compiled at the end of 1699. B. M. MS. Add. 26269, p. 320.

(6) *Aḥvāl-i-Salāṭīn-i-Bījāpūr.*—An abridged history of the 'Ādil Shāhīs from their origin to the conquest of Bījāpūr by Aurangzīb, 1097 A.D. By Pīrzāda Ghulām

Muḥiyyuddīn. Compiled in A.H. 1221. MS. B. M., Add. 26270.

(7) *Basātīnus-Salāṭīn.*—A History of the 'Ādil Shāhīs from their origin to downfall. By Muḥammad Ibrāhīm Zuhayrī. Compiled in 1824 A.D. B. M. MS., Add. 26269. India office Persian MS. 3406.

(8) *Ma'āṣir-i-'Ālamgīrī.*—By Musta'id Khān, 1710 A.H. B. M. MS. 270a., 936b., printed in the Bibliotheca Indica Calcutta, 1870-1.

(9) *Dilkushā.*—By Bhīmsen, 1708 A.H. B. M. MS. p. 271a, or 23.

(10) *Futūḥāt-i-Ālamgīrī.*—By Ishardās, compiled in 1109 A.H., p. 269a. Add. 23884.

HISTORY OF BAḤRĪ'S TIME

The Decline of the 'Ādil Shāhs.

Just as the Bījāpūr Kingdom had originated in a military revolt so its decline was marked by the dismemberment of the kingdom into a number of military fiefs. The Government was a military occupation carried on by the dominant aristocracy and the officials of the state, *i.e.*, the Afghans with their fiefs round Mīraj and Bankapur, the Abyssinians ruling over the eastern province, the Sayyids and the Arab Mullās of the Navāyat clan of Konkan who were alien in origin, but had settled in the country and had no intention of returning to their respective homes. They married within their own tribes and so there could have been no bond of loyalty between them and those whom they governed. Such a state could not be called national and was evidently doomed to a speedy dissolution.

For twenty years after the year 1636 Bījāpūr enjoyed a period of undiminished splendour. Owing to a treaty

between 'Ādil Shāh and the Mughals, Bījāpūr was left free from attack, and so by 1656 its territories stretched from the Arabian Sea to the Bay of Bengal and it was surrounded by a fringe of tributary states.

Though the early years of 'Ali 'Ādil Shāh were disturbed by quarrels among the nobles and rebellions in the frontier provinces, which were further aggravated by Aurangzīb's invasion of Bījāpūr, 1657, the middle and later years of this king's reign were marked by a greatness scarcely less conspicuous than that of his father's reign.

In 1672, on the death of 'Ali 'Ādil Shāh, the glory of Bījāpūr departed. His son Sikandar was only a boy of four at the time of his father's demise and consequently the affairs of the state were entrusted to one regent after another in quick succession. The country became a prey to their selfish greed.

It was a period marked by a chronic civil war among the factious nobles and independence of the provincial governors; the administration of the capital itself was paralysed and the country was disturbed by occasional but indecisive Mughal invasions.

Under an infant king and the incapable regent *Khavāṣ Khān*, the monarchy began to decline rapidly. Disaster after disaster followed on all sides and Aurangzīb launched his campaign in the Deccan which proved fatal to the continuance of the 'Adil Shāhī kingdom. One of the most humiliating terms of the treaty of Gulbarga was that the Sultan's sister should be sent to the Mughal harem to be married to Prince A'ẓam. She refused to desert her brother Sikandar, but at last had to yield to the demand of the Mughals and left the city of Bījāpūr amidst the tears of the citizens.[1]

[1] *Basātīnus Salāṭīn*, p. 424.

The revolt of the Afghans under Bahlol Khān drove the regent to beg the aid of the Mughal Viceroy in pacifying the Afghans or extirpating them. It was an aid which was promised in return for co-operation from the 'Ādil Shāhī troops in the attack of the Mughals on Shivā.

Unfortunately for Khavāṣ Khān, Bahlol Khān heard of this arrangement, and struck first. It was an easy matter for him to abduct Khavāṣ Khān, fling him into prison and seize the regency without striking a blow, for owing to the unpopularity of the Abyssinian no one was prepared to support him.

Bahlol Khān and his Afghan soldiers proved even more incompetent than Khavāṣ Khān. As a result of this fact there was soon disorder and confusion in the country which finally ended in civil war.

From 1680 to 1683 the 'Ādil Shāhīs were free from foreign attack, but this relief was too late to be of any use, for their monarchy by now was in the last stages of dissolution.

Aurangzīb attempted to enlist the assistance of Bījāpūr in his contemplated attack on Shambhu of the Deccan, but no response came to the Emperor's appeal. On the contrary, he received repeated and clear proof of the help that the Marathas used to get from the Bījāpūr Government. So Aurangzīb decided to increase the pressure on Shambhu by making a diversion against the Bījāpūrīs, and compelling them to concentrate their resources on the defence of their own realm. Accordingly sundry and desultory attacks were launched against Bījāpūr, which effected no conquests beyond subduing defenceless villages and the surrounding corn-fields.

The Emperor personally came to Aḥmadnagar to carry on the campaign, but as the Mughals were at this time fully occupied with the Maratha war, it was not until 1685 that Bījāpūr itself was besieged.

The city was now in a lamentable condition. Sīdī Mas'ūd, who had for the last five years, as vazīr, struggled to reform the Government and restore order and peace in the country, failed in his attempt and left it in disgust.[2]

His successor, Agā Khusraw, died after six months in 1684. Sikandar 'Ādil Shāh himself was forced to undertake measures for the defence of Bījāpūr. In spite of Aurangzīb's friendly advances, Sikandar 'Ādil Shāh declined to change his decision to support Shambhu and replied defiantly to all the Emperor's overtures, entreaties and commands which he made repeatedly to bring him round to his side. This incident led to the siege of Bījāpūr in 1685.

At first the Mughal operations were languidly carried on, for the Mughals were not sufficiently expert and alert in capturing forts by siege. The garrison, fighting in behalf of the adversary, was so active and prompt in making sallies on the besiegers that the Mughals were unable to hem the fort round and prevent all entrance and exit.

The arrival of allies from the Deccan stimulated the energies of the Bījāpūrīs to such an extent that they were able not only to create diversions in other parts of the country but to cut the Mughal lines of communication, so that Mughals began to suffer from scarcity of food. Had it not been for the courage of Prince 'A'ẓam, who was in sole charge of the Mughal forces, the siege would probably have been abandoned altogether.

The author of Maāṣir-i-'Ālamgīrī relates a very touching incident regarding Prince 'A'ẓam's dauntless determination to carry on the siege at any cost. When the prince found his chief officers wavering, he gathered them together and asked them if they were really willing to co-operate with him in his endeavour to capture the fort

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[2] *Basātīnus Salāṭīn*, p. 443.

of Bījāpūr. He added that so far as he and his two sons were concerned they would not budge an inch from their post of danger so long as they breathed. In reply to this appeal all the officers cried with one voice and assured the prince that they were of one mind with him and they would do everything for him and his campaign.

When Aurangzīb heard of his son's bravery he sent fresh supplies and reinforcements to the camp. The news that the Imperialists had succeeded in subduing the Marathas inspired the Mughal army with new zeal and vigour to accomplish their task. In spite of the fact that the Emperor arrived in person on the scene of the war and in order to accelerate the conquest of Bījāpūr took the command into his own hands, it took full seventy days before the siege was brought to a conclusion. When at last the city fell, its fall was not due to any organised assault. Aurangzīb's grim determination, zeal and self-sacrifice, combined with the confusion within the city, caused the Bījāpūris to lose heart. They felt that the 'Ādil Shāhī monarchy was tottering to its fall and that its cause was hopeless. It was hardly a worse lot for the puppet king to become the pensioner of Aurangzīb than to live as the protégé of his own regents and ministers.

In these deplorable circumstances the city of Bījāpūr fell into the hands of the Mughals and Sikandar, the last of the 'Ādil Shāhī Sultans, renounced his hereditary title and the throne and threw himself on the mercy of the Mughal Emperor, who at first treated him with the consideration and honour due to his rank and seated him next to his son in the open *darbār*. Sikandar's[3] property at Bījāpūr was, however, attached and he was ultimately led away into captivity, in which he languished for fourteen weary years until at last death released him, at the foot of

[3] Ishwar Dās, 104. *Dilkushā*, 202.

Satārā fort which Aurangzīb was trying to capture. In deference to his wishes he was buried in Bījāpūr near the tomb of Shaikh[4] Fahīmullāh, his spiritual preceptor.

Bījāpūr then presented a dismal appearance, as all its former grandeur and glory had departed. It was made the seat of a provincial governor. The revenue of a kingdom was no longer spent on the city as it had been formerly. Most of the noblemen, magnates and members of the royal family, who at one time had adorned the city with their presence and retinues, had either disappeared or died. Thus there was no one to patronise and encourage the cultivation of the fine arts and poetry, which had been fostered by the 'Ādil Shāhī kings and the noblemen of the time. Two years later more than half the population was swept away by a devastating plague, which removed the few cultured men who had survived the ravages of time. Thenceforth Bījāpūr lost all its glory, culture and fine arts, which are still traceable in its numerous decaying but wonderful monuments and in its soul-inspiring mystical poetry, which has been rescued from total oblivion through the commendable efforts of a few lovers of literature.

Condition of Society in Aurangzīb's Time

The aftermath of Aurangzīb's conquest of the kingdom of Bījāpūr is seen in the utter desolation and deterioration of the people with its attendant decline of the fine arts and, what is more deplorable, in the low intellectual type of the people who lived in those days.[5] Dominated by the self-sufficiency of Aurangzīb who would delegate no responsibility to his sub-ordinates, the younger

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[4] *Basātīnus Salāṭīn*, p. 455.

[5] *Dilkūshā*, 11 150 b.

generation grew up without any initiative or ambition for progress, and with the lack of leisure caused by incessant warfare the culture of the aristocracy decayed. Along with it the intellectual level of all classes in India sank to a lower stage. In the letters, anecdotes, and even in the works of thoughtful historians of the time ample proof of the *moral* decay of the governing classes are found. Public service was not open to talented and well-educated people, but was used as a means for making provision for the kinsmen of the nobles holding high offices. The decline in moral tone was most noticeable among the nobility, who now gave themselves up almost completely to luxury and idleness. Their harems were filled. Their sons received very little education and were taught to have an inordinately high opinion of their own importance.

The picture of the Mughal Empire *at that time* presents a dark and gloomy appearance. Luxury and vice existed among the nobility; the official classes were so degenerate that bribery and corruption were rife in every department of the state. The previous kings had left the Mughal empire without a rival but by the end of Aurangzīb's long reign the conditions changed considerably. The country was steeped in confusion, chaos and heart-rending misery. It was drained by Aurangzīb's wars in the Deccan extending over a quarter of a century. The mischief done by the Maratha raiders, the large number of sieges and the wholesale burning of houses, combined to present a most desolate scene. The country's plight was aggravated by the ravages of pestilence, excessive rainfall and floods. The peasantry in utter exasperation took to robbery. They joined the Marathas in their raids and added to the existing misery. Thus travelling became unsafe and trade was dislocated. This state of affairs badly affected the village industries, resulting in the economic impoverishment of the country.

The accumulated treasures of his ancestors were utilized by Aurangzīb in carrying on a series of wars in the Deccan which emptied the treasury of the state. Lawlessness prevailed. The Governors of provinces could not suppress the rebels and check the growing unrest and political disorder.

The last years of Aurangzīb's reign were marked by disorder and civil war all round. The country was plunged into misery and became a prey to spoliation.

The following memoirs of Urdu poets have been consulted in collecting material for the life and works of Qaẓī Maḥmūd Baḥrī and his contemporary poets :—

(1) *Tazkira.*—by 'Alī Ḥusayn Gurdezī. MS. B. M. OR. 2188.

(2) *Gulzār-i-Ibrāhīm.*—by Navvāb 'Ālī Ibrāhīm Khān. MS. B. M. Add. 27319.

(3) *Tazkira-i-Hindī.*—by Ghulām Hamdānī Muṣḥafī. MS. B. M. OR228.

(4) *Divān-i-Jahān.*—by Beni Nārāyan, poetically surnamed Jahān. MS. B. M. Add. 24043.

(5) *Gulshan-i-Bekhār.*—by Navvāb Muḥammad Muṣṭafā Khān Shīfta. MS. B. M. OR2164. Also printed copy in my possession.

(6) *Makhzan-i-Nikāt.*—by Muḥammad Qiyāmuddīn Qā'im, composed in 1754 A.D. MS. India Office Library, p. 3522. Also printed copy in my possession.

(7) *Majmū'a-i Naghz.*—MS. India Office Library, p. 3123.

(8) *Gulshan-i-Hind.*—by Mirzā 'Alī Luṭf. MS. India Office Library, p. 3126. Printed copy in my possession.

(9) *Gulistān-i-Bekhezān.*—by Ḥakīm Sayyid Ghulām Quṭbuddīn Bāṭin Dihlavī. A copy in my possession.

(10) *Nikātush Shu'arā.*—by Mīr Taqī Mīr. Published by the Niẓāmī Press, Badāun, India. A copy in my possession.

(11) *Tazkira-i-Shu'arā-i-Urdū.*—by Mīr Ḥasan Dihlavī. Published by the Anjūman-i-Taraqqi-e-Urdū, Aurangabad. A copy in my possession.

(12) *Gulshan-i-Guftār.*—by Khvāja Khān Ḥamīd Aurangābādī. Edited by Sayyid Muḥammad and published by the Maktaba-i-Ibrāhīmiā. A copy in my possession.

(13) *Camanistān-i-Shu'arā.*—by Lachmī Narāyan Shafiq. Published by the Anjūman-i-Taraqqi-e-Urdū, Aurangābād. A copy in my possession.

(14) *Tazkirāe-Shu'arāe-Dakkan.*—by A. Jabbār Khān Malkāpuri. A copy in my possession.

(15) *Panjāb Mē Urdū.*—by Maḥmūd Shīrānī. Published by the Anjuman Taraqqi-e-Urdu, Lahore. A copy in my possession.

(16) *Urdū-i-Qadīm.*—by Sayyid Shamsullāh Qādirī. Published by the Tāj Press, Hyderabad, Deccan. A copy in my possession.

(17) *Ḍakkan Mē Urdū.*—by Naṣīr Uddīn Hāshimī. Published by the Niẓām-i-Dakkan Press, Hyderabad, Deccan. A copy in my possession.

(18) *Rauẓatul-Auliyā-i Bījāpūr.*—by Sayyid Shāh Sayfullāh Qādirī. Published by the Ṣibghatu'llāhī Press, Raicur. My own copy.

(19) *Urdu Shāh Pāre.*—by Dr. Muhiyyuddīn Qādirī. A copy in my possession.

II

BAḤRĪ AND HIS CONTENPORARIES

Before writing anything about Baḥrī and his contemporaries it is necessary to take stock of the sources from which material can be drawn in order to form an estimate of the lives and outstanding characteristics of the poets.

Accounts of the poets and their works can be obtained only from *Tazkiras*, *i.e.*, memoirs of poets.

Urdu poetry was designed on the model of Persian poetry, and so the Urdu *Tazkiras* were also composed on the lines of Persian *Tazkiras*.

The fact that Urdu literature had reached a high level of development in the Deccan may lead people to presume that the art of *Tazkira* writing had been in vogue for long. Moreover, the encouragement and patronage which Urdu poetry received from the 'Ādil Shāhī and Quṭb Shāhī kings and the popularity which it gained in Golkunda and Gujrat, are likely to strengthen the presumption. But, so far, no authentic evidence is available to prove that any such memoirs were written in the Deccan in those days when Urdu poetry was cultivated.

Mīr Taqī Mīr's *Nikātūsh-Shu'arā* is generally considered to be the earliest memoir of Urdu poets. The date of the compilation of this memoir is not given, but it can be approximately fixed at about 1752 A.D. by closely studying the contents of the book and taking into consideration necessary relevant evidence. Besides *Nikātūsh Shu'arā* there was another *Tazkira* by Fatḥ 'Alī Gurdezī which was perhaps written in the same year. The Anjuman Taraqqi-e-Urdu has published the former, whereas the latter is still unpublished. The MS. by Fatḥ 'Alī Gurdezī is available at the Āṣafia Library, Hyderabad, Deccan, and the British Museum OR2188. The third

Tazkira-Makhzan-i-Nikāt, by Qā'im Cāndpūri, was compiled two years later.

In the 3rd quarter of the eighteenth century *Camanistān-i-Shu'arā* (1761 A.D.) and *Gulzār-i-Ibrāhīm* (1784) were written, in addition to these just mentioned. So far as we know, these are the only memoirs of the early Urdu poets. They were written after the models of the Persian memoirs. The influence of Persian was so great that these were written in Persian instead of Urdu. These memoirs, evidently, do not throw any light upon the origin and development of Urdu, nor do they give us any insight into the characteristics and the tendencies of the periods. Thus all the salient features which characterise the literary history of a country and which should have been mentioned are ignored; even the names, ordinary incidents of the poets' lives and the dates of their birth and death are not accurately recorded. The aim and object of the writing of memoirs is to prepare an anthology consisting of the choicest selections from the works of various poets. Both the ancient and modern writers of the Urdu *Tazkiras* were merely content with giving meagre information by way of introduction without mentioning full facts. This was all that was considered to be necessary in the art of *Tazkira* writing.

In most cases a *Tazkira* is arranged in alphabetical order, but some of the writers have not even kept this order in view. They have jumbled up poets of various places and of various periods.

Of all the memoirs *Makhzan-i-Nikāt* is the only *Tazkira* which the author has divided into three periods :—(1) early, (2) middle, and (3) modern—and has arranged the poets accordingly.

With all their imperfections and shortcomings, the memoirs of Urdu poets, mentioned in the list on pp. 275 and 276 are the only sources from which we can draw our

material. There is nothing else on which we can fall back for help and guidance regarding the life and characteristics of the poets of a certain period. While doing so we have to be very careful and cautious in sifting fact from fiction, because some of the writers have unduly lavished praise on some poets and have underrated others whom they did not like, without making any adequate literary criticism of their comparative merits and demerits.

Most of the *Tazkiras* were written by poets living in the north of India, so they were not in close contact with the poets who flourished in the Deccan. That is why only a very few poets of the Deccan have been mentioned by Mīr Ḥasan, Mīr Taqī Mīr, Fatḥ 'Alī Gurdezi, Mir 'Alī Luṭf, Āzād and 'Abdu'l Ḥayy. They do not seem to have taken pains to gather fuller accounts of the poets whose memoirs they have chronicled. Sayyid Muḥammad, in his introduction to *Gulshan-i-Guftār*, page 8, says that " when the two early *Tazkira* writers, Mīr Taqī Mīr and Fatḥ 'Alī Gurdezī, were engaged in the compilation of their respective *Tazkiras*, they came in contact with one Sayyid 'Abdul-Valī 'Uzlat who had gone to Delhi for a visit from his native place in the Deccan and had with him his note book in which he had jotted down a number of stray couplets of the Deccani poets whom he appreciated. This commonplace book was shown to Mīr and Gurdezī, who copied out the couplets of the Deccan poets, with their names and brief accounts of their lives." It seems probable that they, without making further inquiries about the poets, incorporated the couplets and the account in their respective memoirs.

The following poets are generally mentioned in these memoirs written in the north of India:—Valī 'Ājiz, Sirāj, Dā'ūd, Āzād and Aḥmad. *Makhzan-i-Nikāt* by Qā'im Cāndpurī, *Camanistān-i-Shu'arā* by Shafīq Aurangābādī and *Gulshan-i-Guftār* by Khwāja Khān Ḥamīd

Aurangābādī have been discovered and published during the course of the last six years. The writers of these three memoirs were all Deccanis. It was expected of them that they would give better accounts of the Deccani poets than those recorded by the memoir writers of the north of India, but unfortunately, they too, have not done full justice to all the illustrious poets. The *Gulshan-i-Guftār* has chronicled only brief sketches of the lives and given poems of thirty poets in all, including seventeen Deccani poets. A host of first-rate poets such as Mirānjī, Jānam, Amīnu'ddīn 'A'lā, Wajdī, Baḥrī, Nūrī and Nishāṭi finds no place in the book. Similarly in *Camanistān-i-Shu'arā* and *Makhzan-i-Nikāt* many of the Deccani poets have not been mentioned.

Two books published a few years ago in Hyderabad Deccan, one by Nasīruddin Hāshimi called *Dakkan mē Urdu* and another *Urdū-i-Qadīm* by Shamsullāh Qādirī alone contain some reference to Baḥrī and a few of his contemporaries :—

(1) *'Ājiz* was one of the Baḥrī's contemporaries. His name was Muḥammad 'Alī. He was a resident of the Deccan but it is not yet known where he lived. So much is certain that he lived during the conquest of the Deccan by Aurangzīb in 1707. He left behind him the following works :—

(*a*) *Qissa-i-Fīrōzshāh.*—In the reign of Manūcehr Khān ruler of Mashhad 1034—1074, Maḥbūbū'l Qūlūb, a Persian prose book was written. It contained various kinds of stories and anecdotes. One of the stories about Fīrozshāh was rendered into Urdu poetry of 'Ājiz. A manuscript of 'Ājiz's *Masnavī* is preserved in the India Office Library and contains about 400 couplets. It was composed in 1688 A.D. The date is given in the colophon.

(b) *Qissai Lāl-o-Gauhar* contains the love-story of Lal, son of Zamurrad Shāh of Bengal, and Gauhar, daughter of Javāhir, Shāh of Nagīna. This story is published in Bombay. Garçon de Tassy has summarised it in French and has published it as an appendix to his history of Urdu literature.

(c) *Qissa-i-Malika-i Miṣr.*—This story is also rendered in Deccani Urdu poetry by 'Ājiz. Its opening line is :—

رکھا ہے معلق زمیں آسماں * چلاتا ہے یونت زمین و زماں

There is another 'Ājiz who was a contemporary of Baḥrī. His name was 'Ārif 'Alī Khān alias Mīrzāī. Mīr Taqī Mīr, Shafīq Aurangābādī, the author of *Tuḥfat-ush-Shu'arā* and Ḥamīd Aurangābādī have recorded their personal knowledge of him. Mīr met him in Delhi and heard him reciting his poems. From Delhi 'Ājiz went to Burhānpūr. Mīr confesses that he does not know anything more about him.[6]

Shafīq Aurangābādi met him in Hyderabad (Deccan) and thought much of him as a poet of varied attainments. In his *Taẕkira*, the *Camanistān-i-Shu'arā*, page 463, he says that " there is not a single poet in the Deccan who could surpass him in poetical gift." He was an excellent chronogram writer.[7]

The author of *Tuḥfatush-Shu'arā* (an unpublished MS. in the Āṣafīa Library quoted in the footnote of *Gulshan-i-Guftār*) says that 'Ārifuddīn Khān 'Ājiz came from Balkh to India in the reign of Aurangzīb and was appointed an officer in the court of Ghāziu'ddin Khān Bahādur. He considered 'Ājiz a high-class poet who

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6 *Urdu-i-Qadīm* by Shamsullah Qādri, pp. 84, 86.
Garcon de Tassy, Vol. I, p. 168.
Nikātush Shu'ara, pp. 102-103.

7 *Camanistān-i-Shu'arā.*

was capable of writing various kinds of poems and was an adept in the composition of chronograms. He composed poems both in Persian and Urdu and left a *Dīvān*.

Ḥamīd Aurangābādī's version is different from the first three chroniclers. He says that 'Ājiz carried on trade in Gujrāt and received financial assistance from its Governor, Fakhru'd-Daulā when his business failed.

He was a quick-witted poet and most of his couplets conveyed a double meaning. He was averse to reciting his couplets to his friends and admirers. He also composed some undotted Qaṣīdas. He had to his credit a Dīvān in Persian and Urdū which contained some purely Hindi rhymes also.[8]

Some specimens of his poetry are quoted below :—

عرق جب اس پري کے چهرۂ پُرنور سے تپکے
خجل هو گُل سیں شبنم جیوں لهو ناسور سے تپکے
اگر اس زلفِ مشك آمیز سیں چیني میں بال آوے
عجب نیں عطر عنبر کاسۂ فغفور سیں تپکے
بهروں جب آہ کا دم اپنے گلگوں پوش بِن عاجز
دم اِسرافیل کا لوهو هو بانگِ صور سے تپکے
فلك سرکش هوا اس بارِ غم سیں چرخ کها ڈوهرا
رهیگا تا قیامت میں همارے درد کا شهرا
لکهوں زهرہ جبیں کے گال کي ذرّہ اگر خوبي
کروں میں صفحۂ خورشید پر یاقوت سوں مُهرا
لکهوں کیا خوبیاں وہ حسن عالمتاب کي عاجز
وہ رشك مِهر کي روشن جبیں سے هو گیا زهرا
طبیب اُٹهہ جا سرهانے سیں علاج اب هو چکا میرا
جهاں میں کهیں بهي جیتے هیں دِوانے زلف کے مارے

[8] *Gulshan-i-Guftār*, pp. 58—62.

خدا جانے دوانا دل کدھر جاتا رہا میرا
صبح سبن شام لگ آھوں کے دوڑاتا ھوں ھرکارے
شب اُس مہتاب رو کو دیکھہ کر عاجز عرق افشاں
کلیجہ پھٹ گیا مہتاب کا گننے لگا تارے

(2)[9] *Amīn* (about 1698). His name was Shai<u>kh</u> Muḥammad Amīn. He rendered the *Yūsuf Zulai<u>kh</u>a* into Da<u>kh</u>anī Urdu verse in 1697 A.D. just three years before Baḥrī completed his *Man-Lagan*, 1700 A.D. 1112 A.H. Dr. Sprenger states in his catalogue that he saw a copy of this MS. in the library of the Kings of Oudh. It contained 300 pages and its opening line ran as follows :—

اَول تعریف سن خالق کي اے یار
کہ وہ دونوں جہاں کا ھے کَرَن ھار

He wrote another book called *Qiṣṣa-i-Abū Shahma*, a copy of this MS. is preserved in the India Office library from which the following couplets are quoted :—

دنیا میں بزرگي سخن کو اھے
سخن تے بزرگي بشر کو اھے

سخن تے ھوے او جو غافل بشر
سخن جس میں ھے سو آو کامل بشر

سخن کا سبوں میں بڑا اعتبار
سخن تیچ دنیا اھے برقرار

دلاتا ھے سب کوں سخن دولتاں

پنا تا ھے سب کوں سخن کسوتاں

سخن خوب ھے سب جواھر منے
سخن کے جواھر اھے سب کنے

[9] Sprenger, p. 601; *Urdū-i-Qadīm*, p. 88.

(3) *Z̤auqī* (about 1698). His name was Sayyid S͟hāh Husain Z̤auqī and the title conferred on him by his spiritual guide was Bahrul 'Irfān (Sea of Wisdom). He had a religious bent of mind, and did not cultivate the art of poetry as a vocation. He was dissatisfied with the lack of appreciation because no Deccani King patronised him. He was, however, glad that he had the privilege of living in the reign of a pious and God-fearing king like Aurangzīb.

The following lines are quoted from one of his *marṣiyas* preserved in the Edinburgh University Library.

اے شمع بزم مرتضی گھر آج آتے کیوں نہیں
تاریك هے تم بن جہاں جلوہ دکھاتے کیوں نہیں [10]

وہ شمع بزمِ مصطفی بادِ اجل سوں گُل هوا
سب سوز دل سوں تن سدا یاراں گلاتے کیوں نہیں

چھوڑو سگل دنیا کے کام دس دن تلك اے خاص و عام
ماتم کے آتش میں مدام تن کوں جلاتے کیوں نہیں

ذوقي تمہارا هے غلام، فضل و کرم سے یا اِمام
اپنی زیارت کوں مدام اُس کُوں بلاتے کیوں نہیں

(4) *Aḥmad* (1700). Mīr Ḥasan and Qā'im speak of him in their *tazkiras*, as Aḥmad of Gujarāt. In another memoirs called *Iyār-Ushu'arā* (India Office MS. p. 3131) he is described as living in Burhānpūr. According to this memoir his name was G͟hulām Aḥmad 'Alī. S͟hafīq Aurangābādī considers him a poet of high order who wrote on the model of the old poets. Mīr Ḥasan simply contents himself with remarking that "he lived long ago and nothing more is known of him."

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[10] *Urdu S͟hāh Pāre*, Vol. I, p. 306.

Mīr Taqī does not say a word about him but quotes more of his verses than of others. Some of them are as follows :—

نین لے ہاتھہ میں کھپرے پھریں درسن کی بھکیاں کو
نپاے ایک در پر بھي بھکاري در بدر نکلے

رہے نادر خیالاں میں ملے شوریدہ حالاں میں
ہوے صاحب کمالاں میں کدھر سے آ کدھر نکلے

ہوے دیدار کے طالب خودي سے خود گذر نکلے
نہ پاے راہ دانش میں خروشاں بےخبر نکلے

نشانِ بےنشاں ہم ملک یک رنگي میں پاتے ہیں
خبر چھوڑي دوئي کي ہم نے جب سے ستنگر نکلے

بھرے دو نین کے چھلکاں صبوري ساتھہ بے توشہ
کمر ہمت سے باندھے ہو پرت کے بات پر نکلے

(5) *Valī of Velūr* (1707). Shamsu'llāh Qādirī* calls him "Valī Dakhanī." His name was Sayyid Muḥammad Fayyāz. Mullā Muḥammad Bāqir Agāh writes in the introduction of *Mirātul Jinān* that he was a resident of Velūr and flourished during the reign of Aurangzīb. He was a courtier of Navvāb Ḥirāsat Khan of Satgaṛh in the Deccan. After some time he travelled to Kaḍapa (now in the Madras Presidency) where he was introduced to Navvāb 'Abdul Majīd Khān, Ṣūbedār of that district, who appreciated his poetic gifts and appointed him an officer at Sidhoṭ the fortress which is particularly mentioned by Ibn-Nishāṭi in the epilogue of his *Phūl Ban*.

Valī seems to have been a prolific writer, for two of his three known works are extraordinarily bulky.

(a) *Ratan Padam*. This *masnavī* is not extant. Sprenger mentions it in his catalogue as having been preserved

* Urdū-e-Qadīm, p. 89.

in the library of the kings of Oudh. It dealt with the love story of Queen Padmāvat and Ratan Sen, the *raja* of Citaur. The *masnavī* contained about 4000 couplets and had 400 folios.

Shamsu'llāh Qādirī has quoted the following verses from the preface of Padmāvat in the Urdū-e-Qadīm, p. 89, and does not mention where he came across this book.

حراست خاں امیر اك نامور تھا
سکونت گاہ اوسکوں ساتگڑھہ تھا

اتھا او اھل درد و نیك اعمال
رفاقت میں اتھا میں اُسکے خوش حال
قضارا واں سوں ھو قسمت تے برخاست

سو آیا میں طرف کڑپہ کے دھر خواست
نواب عبد المجید ابن الحمید ایك

اتھا واں نامور صوبہ سعید ایك
سو او بحر سخا پروانہ لکھہ کر
بہ سلك نوکراں میں منسلك کر

تعیّن مجکوں سدھوت کو روانہ

کیا او صاحب شیریں زمانہ

سوحسب الحکم میں سدھوت کو آیا

رنگا رنگ واں تماشے میں نے پایا

(b) "*Rauzatush-Shuhadā*. His second work has been published several times and there is a good MS. of it in the India Office Library. The date of the book is given as 1720 A.D. in the India Office copy, whereas the published copy bears the date 1707 A.D. Valī's Rauzatush-Shuhadā is based on Mullā Ḥusayn Vā'iz Kāshifī's Persian book having the same title. It was also called *Dah Majlis* as it is recorded in its MS. in the Bodleian Library (see catalogue, p. 78b).

[11] The Bombay edition, 1291 A.H.

Shamsullah Qādirī states in the *Urdū-i-Qadīm*, page 91, that Valī wrote a book of *Munājāt* also. It contains 25 *bands* and each *band* consists of four distichs. The following lines are quoted by him :—

یاالٰهي زهد تقوی نیں هوا منجهه هات سُوں
کچهه عبادت هور ریاضت نیں هوا منجهه ذات سوں
سر بسر هوں منفعل اِس کام هور اِس بات سوں
یا غفورالمجرمیں منجهه حال پر احسان کرو

یا اِلٰهي از طفیل انبیا هور اولیا
غوث اور اقطاب هیں جتنے جهاں کے اصفیا
آبرو رکهه دو جهاں میں هے ولي کي التجا
هے او بندہ کمتریں منجهه حال پر احساں کرو

یا اِلٰهي تو بحقِ مصطفےٰ هور مرتضےٰ
فاطمهه خاتون جنّت هور شاہ کربلا
عاقبت توں خَیر کرنا عرض هے میري سدا
یا صاحبِ عرشِ بریں، منجهه حال پر احساں کرو [12,13,14]

(6) *A<u>sh</u>raf* (about 1716). Sayyid A<u>sh</u>raf[15] is one of the good poets of this period. From his intense devotion to the <u>Kh</u>alīfa and his successors and his numerous elegies composed in their honour it may safely be inferred that he was a devout Shiʿa. Some of his poetical compositions are preserved in the British Museum MS. Add. 1590 and the Edinburgh University Library. His works do not throw any light on his life. Sprenger mentions in his catalogue that he was a contemporary of Valī and nothing

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[12] Introduction to *Mirātul-Jinān*, p. 3.

[13] *Rauzatu<u>sh</u> <u>Sh</u>uhadā*, Bombay edition, 1291 A.H.

[14] *Urdū-i-Qadīm*, p. 91.

[15] *Urdu Shāhpāre*, p. 147.

else. Shafīq Aurangābādi[16] also corroborates this meagre quoting the following verse[17] :—

اشرف کا یو مصراع ولی مجھکو ھے دل چسپ
اُلفت ھے دل و جاں کو میرے پیتم نگر سوں
تو شاہ ھے سب شہوں کا بندے ھیں ترے سب شاہ
میں بھی اَپس کو بندہ تیرا ، نہ کہوں تو کیا کروں

Mīr Taqī Mīr does not say a word about him beyond quoting the following verse :—[17]

پیا بن، میرے تَیں بیراگ بھایا ھے، جو ھوني ھو سو ھو جائے
بھبھوت آب جوگیوں کا رنگ لایا ھے، جو ھوني ھو سو ھو جائے

Ḥamīd Aurangābādī[18] says that his name was Muḥammad Ashraf and his *nom de plume* was Ashraf. He was a resident of Gujrāt. He was a disciple of Valī Muḥammad and was gifted with poetic genius; his style was florid. His poems are well known in the neighbourhood of Gujrāt and he has left an excellent Dīvān to his credit. The following couplets are quoted by Ḥamīd :—

ھوا ھوں بستۂ زلف سجن شکن کي قسم
ھوا ھوں صیدِ رَم مَن ھَرن ھرن کي قسم
پتنگ وار ھے دل جب سے شمع رو پہ فدا
اگن میں شوق کے جلتا ھے تَن لگن کي قسم
پیا ! دیکھا جو تیرے جامِ چشم کي گردش
ھوا ھوں شوق کي مے سے مگَن نین کي قسم

16 *Camanistān-i-Shu'arā*, p. 35.

17 *Nikātush Shu'arā*, p. 108.

18 *Gulshan-i-Guftār*, pp. 12-13.

(7) *Valī Aurangābādī* (1668—1744 A.D.). In the whole range of Dakhanī poets there is none so well known as Valī of Aurangābād Deccan. All the memoir writers of Urdu poets, whether hailing from the Deccan or the north of India, have noticed him in their Tazkiras and yet none of them has succeeded in gathering adequate and authentic information regarding his life, religion and travels. His name is still shrouded in mystery. There are no two memoir writers who are agreed about his correct name. One calls him Shamsu'ddin, another Shamsul Ḥaqq, a third mentions him as Valiu'ddīn and a fourth thinks his name was Hājī Valī.

All of them agree about his *nom de plume* which they call *Valī*. Maulvī Aḥsan Mārahravi, the latest editor of his complete poetical works, has not fully succeeded in his endeavours to settle controversial points respecting his life, religion and travels.

He is, however, of opinion that Valī was born in 1668 A.D. in Aurangābād Deccan and died in 1744 A.D. in Aḥmadabad, where his tomb is still preserved.

The author of *Urdū-i-Qadīm* is of opinion that Valī travelled in the north of India only in the time of Aurangzīb and not in the reign of Muḥammad Shāh. It was in the course of this itinerary that he paid a visit to Delhi where he stayed for some time and made the acquaintance of the contemporary poets. This is one of the reasons why, of all the poets, Valī's poems are so well known in the North of India and noticed by all the Tazkira writers of that country. His visit to Delhi gave an impetus to the cultivation of Urdu poetry in the north of India where most of the poets till then composed their poems in Persian. It was their contact with Valī, that made the poets of northern India realize for the first time the immense possibilities of the Urdu language as a vehicle of poetical composition.

From a closer study of Valī's *Kulliyāt*,[19] one can gather internal evidence to the effect that he was a constant traveller and that he visited a number of places in Gujrāt, such as Surat and Ahmadabad. The fact that he wrote a Maṣnavī in praise of Surat and described its social and economic condition, shows that he had an intimate knowledge of the place which he could not have acquired without having resided there.

A proof of his having lived in Gujrāt is that he spent some portion of his student life in Aḥmadabad where he became a spiritual disciple of Shāh Nūru'ddīn, who had his fixed abode there.

That he was Dakhanī and not a Gujrātī by descent is proved conclusively by the following couplets in his Dīvān :—

بیومکھہ کي شمع سوں روشن ھے ھفت اقلیم کي مجلس
ولي پروانگي کرتا تري ملکِ دکن بھیتر

ولی ایران و توراں میں ھے مشھور
اگرچہ شاعرِ ملکِ دکن ھے

There is some difference of opinion about Valī's religious creed, as he wrote verses both in praise of the four Khalīfas and of 'Alī and his descendants. His devotion to the former reveals that he was a follower of the Sunni creed, whereas his encomium of 'Alī and the 12 Imāms points to his leanings towards the Shi'a sect. This controversy can be set at rest, by the simple consideration that if he were really a Shi'a, he could never have gone to Shāh Nūruddīn, a well-known Sūfī teacher of the Sunni sect, and begged of him to accept him as his spiritual disciple. It is an indisputable fact that no Shi'a is ever

[19] See Kulliyāt-i-Valī (Aurangabad edition), p. 379.

known to have joined the fold of a Sunnī Pīr and *vice versa*.

Valī was really a stauneh Sunnī and a devout follower of the Suhravardī school of spiritual discipline.

He wrote verses in honour of 'Alī and his successors because 'Alī is claimed by the Muslim mystics to be the originator and pioneer of the Sūfī sect in Islām. It is therefore the bounden religious duty of every Sūfī poet to pay his tribute of praise in honour of 'Alī and his descendants. This explains why in Valī's *Dīvān*, couplets embodying the eulogy of 'Alī and his family are found. Aḥsan Mārahravī has a high opinion of Valī's learning. He thinks that Valī was well-versed in Arabic and Persian prosody and adopted that system for his Urdu verses. This estimate of Aḥsan's is fully borne out by Valī's couplets in his *Kulliyāt*.

Valī was an accomplished poet. He wrote every kind of poetry. We come across in his *Kulliyāt* 422 odes, 7 mustazād, 12 mukhammas, 2 Tarjī'bands, 6 Qaṣīdas, 2 masnavīs, 26 quatrains, 6 qit'as and 40 miscellaneous couplets.

Some specimens of Valī's poetry are given below :—

عشق کے هاتهه سے هوے دل ریش
جگ میں کیا بادشاہ کیا درویش

گریه و گردِ ملامت سے ولي
خانۂ عشق کو تعمیر کیا

جو هوا رازِ عشق سے آگاہ
وہ زمانه کا فخرِ رازي هے

جسے عشق کا تیر کاري لگے
اُسے زندگي کیوں نه بهاري لگے

جو نبي کے نام په جي سوں فدا نهیں
راضي کسي طرح ستي اُس سے خدا نهیں

اے نور جان دیدہ ترے انتظار میں
مدت ہوئي پلك سوں پلك آشنا نہیں
عُشّاق مستحق ترحّم هیں اے عزیز
اُنکے شکستہ حال پر سختي روا نہیں
ڈالے اُکھاڑ کوہ کوں جیوں کاہ اے ولي
عاشق کي سرد آہ کہ جس میں صدا نہیں

رباعي

اے جِیو ڈو عالم کا ترے مکُھہ پہ فدا
محتاج تري ذات سوں سب شاہ و گدا
مجھہ عاجِز بیکس پہ نظر رحم سوں کر
اے منظرِ هر ناظر و منظور خدا

(8) *Vajdī.*[20] His name was Shaikh Vajīhu'ddīn. He was a resident of Kurnul and was a follower of the Ṣūfī creed. He was an author of several Maṣnavīs in Dakhanī Urdu.

(*a*) Maṣnavī *Bāgh-i Jān-Fizā.*—It is a bulky volume and was composed in 1145 A.H. 1732 A.D. The date of its composition is ascertained from the chronogram of two words *Bāgh-i Jān-Fizā.*[21]

In his introduction to this Maṣnavī Vajdī relates the following anecdote which led to its composition :—Once Vajdī paid a visit to Dhārvār where he was staying with one of his friends, Abdul Quddūs, who was a spiritually-minded man and whose spiritual guide, Shāh Ṣādiq was staying with him in those days. During the course of his conversation, Shāh Ṣādiq related an interesting story to

[20] *Urdū-i Qadīm*, pp. 92—94.

[21] *Dakkan Men Urdū*, pp. 7-8.

them and asked Vajdī to translate it into Dakhanī verse. Originally this story was written in Persian.

(*b*) *Pancī Bācā* (*or Nāma*).[22]—It is a metrical translation of Shaikh Fariduddīn 'Aṭṭār's Maṣnavī *Manṭiq-u'ṭ-Ṭayr*. The concluding lines are as follows:—

اصل میں یو تھا کلام فارسي
اهلِ معني کو مثالِ آرسي

خوشتریں تصنیف شیخ نام دار
پیشواے عارفانِ روزگار

شیخ صاحِبدل فرید نامور
خاص جنکا هے لقب عطّار کر

تھا ولے جو فارسي میں یهه کلام
کم سمجهه سکتے تھے اسکو خاص و عام

گر چه میں بھي کچهه نهیں معني شناس
کاں مجھے اسکے سمجھنے کا قیاس

لیکن اسکے دیکهه کر دل چسپ بول
یك بیك یوں دل منے آیا کُلُول

جو موافق فهم اپنے کے ضعیف
اس کتاب خاص کا نظم شریف

قصد کر دکني زباں میں لیکے آؤں
تارهے دنیا منے میرا بھي ناوں

(*c*) *Maṣnavī Tuḥfa-i 'Āshiqān*.—It is also a translation of Shaikh Farīduddīn 'Aṭṭār's Persian Maṣnavī *Gul-o-Hurmuz* which is also called *Khusraw Nāma*.

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[22] A copy in my possession. Published in 1326 A.H. (1908 A.D.) by Karīmī Press, Bombay.

The following two lines are from this *Maṣnavī* quoted by Shamsullāh Qādirī :—

قضارا دسیا مجھکوں یك بار کا
گل و ھُرمُز اُس شیخ عطّار کا
ھوا شوق پیدا منجھے بعدازاں
کہ دکني زباں سوں کروں ترجماں

Shamsullāh Qādirī says in the *Urdū-i Qadīm*, page 93, that this *Maṣnavī* was completed in 1153 A.H. 1740 A.D. The date of its composition is put in a chronogram thus :—

دسي اسکي تاریخ مجکوں عیاں ✵ پچھانو اِسے تُحفۂ عاشقاں
۱۱۵۳ ھجري

The first few lines of this *Maṣnavī* are quoted below :—

کروں پاك دل ھو زباں پاك سوں ✵ ثنا پاك اس عاشق پاك کوں
کہ جن سے ھواھے اوگم عشق کا ✵ اجوں لگ اُبلتاھے خُم عشق کا
پڑیا عکس اس نور کا حسن رُخن ✵ جھلکنے لگا آرسي کے نمن
سو اس آرسي میں کیا جیوں نظر ✵ ھوا عاشق اپنا آپس دیکھکر
اپَس کیاچہ پرتَو کوں معشوق جان ✵ لیا مبتلاھو کے عاشق کي شان
نکل گنج مخفي سے خلوت کے بھار ✵ کیا جلوہ کر کَثرتِ بے شمار[23]

(9) *Faqīrullāh Azād.*—Mīr Ḥasan in his *Tazkira*, says Āzād hailed from Hyderabad (Deccan). He became an orphan in his early childhood. He was loved and befriended by his neighbours. When he attained his majority he fell in love wtih a handsome girl, spent his days in sighs and lamentation, and did not stop in one place. He visited Shāhjahānābād with Firāqī Dakhanī. He was

[23] *Dakkan Men Urdū*, p. 8.

endowed with pathos and composed eloquent verses. May God bless him.[24]

The following couplet is written by him :—

سب صنعتیں جہاں کي آزاد ہمکو آئیں
پَر جس سے یار ملتا، ایسا ہُنر نہ آیا

Qā'im Chāndpurī in *Makhzan-i-Nikāt* on page 7 has repeated the above-mentioned information regarding Āzād.

Shamsullāh Qādirī has also corroborated it in his *Urdū-i Qadīm* and says that Āzād was a contemporary of Valī Dakhanī. So does Shafīq Aurangābādī, p. 31.

(10) *Dā'ūd.*—His name was Mirza Dā'ūd Beg and his poetic name Dā'ūd. He was a Mughal by descent and a resident of Aurangābād (Deccan). Although he was not well versed in grammar and prosody, his poetry is free from errors. He was endowed with a fertile imagination and had a cheerful disposition. He always wrote on a new and untrodden theme. He was one of the contemporaries of Shāh Sirāj and had adopted the profession of embroidery in his youth.

He won name and fame as a poet of high order. Once he composed a couplet addressed to Shāh Sirāj which is as follows :—

چرب زباني نہ کر بزم سخن میں سراج
تیغ سیں گُلگیر کے ورنہ کٹے گا سَر آج

In reply to this couplet Sirāj wrote the following verses :—

نہ دھرل کسب قدیمي کو اپنے اے مِرزا
وگر نہ بچّہ کہیں کارچُوب ہوئیگا[25]

[24] *Tazkira-i-Shu'arā-i Urdū*, p. 40.

[25] *Gulshan-i Guftār*, pp. 57-58.

Shamsullāh Qādirī[26] says that Dā'ūd was one of the contemporaries of Valī Dakhanī and died in 1168 A.H. 1754 A.D. Lakshmī Narayan Shafīq[27] records his interview with Dā'ūd's son, Mirzā Jamālullāh 'Ishq and on his authority he chronicled the date of Dā'ūd's death which can be deduced from the following distich :—

ع گو برفته میرزا داؤد فاني از جهاں

Qādirī says that he has seen one Dīvān of Dā'ūd from which he has quoted the following verses :—

اس صنم کے خیال آبرو نے
ناتواں مجکو جوں هلال کیا

میرا احوال چشم یار سے پوچھه
حقیقت درد کي بیمار سے پوچھه

چاندني کی سیر کو کس طرح نکلے وہ صنم
دیکھنے مہ کا تماشا' آفتاب آتا نہیں

Shafīq Aurangābādī says that he had come across a Dīvān of Dā'ūd containing 500 couplets from which he has gleaned the following few lines :—

عزیزاں خواب میں دیکھا هوں آج اُس سرو قامت کو
هوا معلوم وقت آیا هے میري سرفرازي کا

مسند هے اهل دل کو بساط زمین کا فرش
هے بے ریا کو بوے ریا نقِش بُوریا

قانون شِفا نُطق میں هے یار کے موجود
اے دل نهو محتاج طبیباں کي دوا کا

یہہ جام چشم مست جیسے تم دکھاؤگے
تا حشر اس کو هوش سے اُس کے بھلاؤگے

[26] *Urdū-i Qadīm*, p. 100.

[27] *Camanistān-i Shu'arā*, p. 88.

دانہ دکھا کے خال کا جس کو دئے ہو چاٹ
آخر کو دام زلف میں اُس کو پھنساؤ گے

آتش عشق سوں ترے جَل جَل
دلِ ہوا دلِ ہوا کباب کباب

کرو مت وعدۂ کَل 'جانِ من' عُشّاق بے کَل سے
جو آپے کل سوں بیکل ہے اُسے کیا کام ہے کل سے

تیمّم اسکا اوروں کے وضو کرنے سے افضل ہے
کیا ہے جس نے حاصل خاکساری کي عبادت کو

(11) *Sirāj* (1127 A.H. 1715 A.D.).—His name was Sayyid Sirāju'ddīn. He was a resident of Aurangābād (Deccan) where he was revered as a saint and a learned man. Mīr Ḥasan and Mīr Taqī write in their memoirs that he was a disciple of Sayyid Ḥamza Dakhanī but the *Tazkira* writers of the Deccan such as Shafīq and Ḥamīd Aurangābādī do not agree with them.

Sirāj has left two Persian and Urdu Dīvāns which contain every type of poetry, *viz.*, sonnets, odes, quatrains, mustazāds, mukhammas and vāsōkht.

He also wrote a *Masnavī* called *Būstān-i Khayāl* which was completed in 1173 A.H. 1759 A.D.

Besides, he compiled a selection of his Dīvān in 1151 A.H. 1738 A.D.

When he completed this anthology, he was 24 years of age. From these data it may be inferred that he was probably born in 1127 A.H. 1715 A.D. The date of his death as recorded by Shamsullāh Qādirī is 1177 A.H. 1753 A.D. In one of his *ghazals*, Sirāj has noted down the date of the selection of his *Dīvān* and his own age at

the time. The three relevant couplets are quoted below :—

جب کیا جزو پریشان سخن شیرازہ بند
تھے برس چوبیس میری عمر بے بنیاد کے
سال ہجری تھے ہزار و یکصد و پنجاہ و یک
واقف علم لدنی صاحب ارشاد کے
اے سراج اس مختصر دیوان کے سب ریختے
خامۂ مژگان خوباں سیں ہیں قابل صاد کے[28]

Mīr Ḥasan,[29] Mīr Taqī Mīr[30] and Qā'im Candpūrī do not furnish more information than this, that Sirāj was a native of Aurangābād and that he lived in the reign of Aurangzeb.

Shafīq Aurangābādī, has, however, devoted a page and a half to eulogising his saintliness and poetic gifts but throws very little light on his life and doings beyond what has just been written.

Shafīq is of opinion that Sirāj was a poet of high attainments and was considered second to none of his time but Valī. Shafīq had read his *Masnavī Būstān-i Khayāl* which he says contained 1,160 couplets. He has quoted a large number of Sirāj's poems in his *Tazkira* from which the following, as specimens, are given below :—

دل مرا بیخودی کے دریا میں ❋ سب سے آزاد ہو نہنگ ہوا
دو رنگی خوب نہیں یکرنگ ہوجا ❋ سراپا موم ہو یا سنگ ہو جا

[28] *Urdū-i Qadīm*, p. 101. (2) *Nikatush Shu'arā*, p. 101.

[29] *Tazkira-i Shu'arā-i Urdū*, p. 109.

[30] *Makhzan-i Nikāt*, p. 9.

تجھکو اے آھو صفت کس نے سکھایا یه طرح
یا تُو تھا اوروں سے رَم یا ھم سیں رَم ھونے لگا

ماجرا سنکر ھمارے اشك بے پایان کا
آب ھو جاتا ھے زھرہ نوح کے طوفان کا

جان‌ودل سے میں گرفتار ھوں کنِ کا، اِن کا
بندۂ بے زر و دینار ھوں کنِ کا، اِن کا

آیا پیا شراب کا پیاله پیا ھوا
دل کے دئے کي جُوت کا کاجل دیا ھوا

جلنا تڑپ تڑپ کر، مرنا سِسَك سِسَك کر
فریاد، ایك جي ھے کِس کِس خرابیوں میں[31]

[31] *Camanistān-i Shuʿarā*, pp. 400—406.

SCIENCE

SECTION I

CHEMISTRY

CHEMICAL EXAMINATION OF THE ROOTS OF *CITRULLUS COLOCYNTHIS* SCHRADER

BY

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INTRODUCTION

Citrullus Colocynthis, called *Indrayan* in Hindustani, *Hanzal* in Persian and *Indravaruni* in Sanskrit, is a plant used in medicine for a very long time. It is a plant of the natural order curcurbitaceæ. As regards its medicinal properties the roots are described by the Sanskrit writers as a useful cathartic in jaundice, ascites, enlargement of the abdominal viscara, urinary diseases and rheumatism. (Dymock, *Pharmacographica Indica*, 1899, *ii* 59.) Mohammedan writers consider the plant to be a very drastic purgative removing phlegm from all parts of the body and direct the fruits, leaves and roots to be used. A paste of the roots is applied to the enlarged abdomen of children.

The fruit of this plant has been chemically examined by Power and Moore (*Jour. Chem. Soc.*, 1910, *47*, 99), but nothing is known regarding the chemical constituents of the roots. Since the roots are used immensely in medicine, in India and elsewhere, it was deemed proper to put it to a thorough chemical examination.

EXPERIMENTAL

A preliminary examination was made with 200 grams of the powdered drug for the presence of alkaloids, when positive reactions were obtained. But all attempts to isolate this in a form of chemical purity failed.

For a complete analysis 2 kilograms of the powdered roots were exhaustively extracted with boiling alcohol in a big extraction flask. The concentrated extract on standing deposited a white crystalline stuff, which on recrystallisation from alcohol melted at 230°C. The mother liquor was then evaporated to dryness and extracted with petroleum ether. This petroleum ether extract on concentration gave a small amount of a white sediment, which on purification melted at 68°C. From its properties and reactions, it was identified as hentriacontane $C_{31}H_{64}$.

The resinous mass left after the treatment with petroleum ether, was then extracted with ethyl acetate The ethyl acetate extract on evaporation of the solvent under reduced pressure yielded a white deposit which was filtered and washed. On recrystallisation from ethyl alcohol it melted at 230°C. From its properties, reactions and elementary analysis it was identified as α-elaterin. This was the same stuff as that obtained from the alcoholic extract in the beginning. A mixed melting point remained undepressed. The percentage was 0·2% of the dried weight of the roots (Found C=69·0; H=7·5; $C_{28}H_{38}O_7$ requires C=69·1, H=7·8%) the di-acetyl-α-elaterin $C_{32}H_{42}O_7$ was prepared in the usual way and crystallised from acetic acid; when it melted at 123-124°C. Previous workers could not obtain this in a crystalline form (*cf*. F. Von. Hemmelmayer, *Monatsh*, 1906, *27*, 1167); but we could get the crystalline acetyl derivative by the slow evaporation of the dilute acetic acid solution.

The brown stuff of the dried alcoholic extract left after the removal of the α-elaterin by ethyl acetate, as described above was then dissolved in boiling water with constant stirring, and treated with basic lead acetate, when an yellow precipitate was obtained. It was filtered, washed, suspended in water and decomposed by sulphuretted hydrogen. The resultant filterate after the decomposition of the lead salt,

on concentration in *vaccuo* gave all the reactions of saponins. It gave on shaking with water a large amount of frothing. A red colouration was developed in cold, on treatment with concentrated sulphuric acid. Concentrated sulphuric acid containing a little ferric chloride gave a blue colouration. All these reactions clearly showed the presence of saponins, but all attempts to isolate it in a purer form could not meet with success.

The filterate obtained after the separation of the lead salt, on removal of excess of lead reduced Fehling's solution easily, and hence contained a large amount of reducing sugars.

SUMMARY

1. From the roots of *Oitrullus Colocynthis* Sohrader, a hydro oarbon hentriaoontane $C_{31} H_{64}$, α-elaterin $C_{28} H_{38} O_7$ and amorphous saponin have been isolated.

2. The orystallised di-aoetyl derivative of α-elaterin has been prepared.

3. The physiological properties of the drug appear mostly due to the presenoe of α-elaterin.

In oonolusion one of the authors (R.R.A.) wishes to express his deep sense of gratitude to the 'Kanta Prasad Researoh Trust' of the Allahabad University for a researoh soholarship.

CHEMICAL EXAMINATION OF THE BARK OF *TERMINALIA ARJUNA* BEDD. PART I— THE ISOLATION OF *ARJUNIN*

BY

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Terminalia Arjuna (N. O. Combretaceæ) called *Arjun* in Hindi and Bengali and *Kukulbha* in Sanskrit is a plant used in Indian medicine for a very long time. It is a large deciduous tree attaining 60-80 feet in height. The bark is ⅓ inch thick, smooth, pinkish grey, the old layers peeling off in thin flakes. It is common in the sub-Himalayan tracts of the United Provinces and Deccan.[1]

The bark and its preparation are reputed to have a distinct stimulating action on the heart from times immemorial. Sanskrit writers consider it to be tonic, astringent and use it in heart diseases, contusions, fractures, ulcers, etc. A decoction of the bark is used as a wash in ulcers and chancers.[2] Some of the Western medical practitioners believe in its efficacy and use it as a cardiac tonic. In 1909 Ghoshal[3] studied the physiological and therapeutic action of the drug. According to him the drug acts as a cardiac stimulant and tonic, increasing the force of the beats of the heart, slowing their action, but never completely stopping it. It acts as a powerful haemostatic, only drawback, according to him, is the rise in the blood pressure. He also recommended it as a di-uretic. He advocated its use as a valuable remedy in heart diseases. Chopra and Ghosh[4] in 1929 mentioned that the drug produces no stimulating effect on the heart such as that produced by the digitalis or caffeine groups of substances, nor it has any marked di-uretic properties; but very

recently in 1930, Caius, Mhaskar and Issac,[5] who made an elaborate and detailed study of all the varieties of *Terminaliæ* met with in India reported that they had di-uretic properties and some had both di-uretic and cardiac stimulating effect.

Regarding the chemical composition of the drug there appears to be much confusion. Hooper[6] in 1891 reported that the bark contains 34 p.c. of ash consisting almost of pure calcium carbonate. Ghoshal[3] found it to contain the following substances: sugars, tannins colouring matters, a body of the nature of glucoside and carbonates of sodium and calcium. Chopra and Ghosh could not find any alkaloid or glucoside, but reported the presence of an organic acid of high melting point, a phytesterol, an organic ester and some colouring matter. Ram and Guha[7] confirmed the presence of two organic acids and a phytesterol. Caius and co-workers also could not detect the presence of any alkaloid or glucoside. These workers reported the constituents of the ash from fifteen varieties of *Terminaliæ* studied by them. Chopra and Ghosh (*loc. cit.*) or Ram and Guha did not give any melting point or other data in support of their arguments regarding the chemical nature of the constituents claimed to have been isolated by them from this important drug.

In view of the fact that so much confusion exists regarding the chemical composition of this plant, the present authors were tempted to put it to a thorough investigation and to isolate the active principle responsible for its therapeutic value as a powerful tonic and di-uretic. Since Chopra and Ghosh (*loc. cit.*) had already tried the petroleum ether, alcohol and aqueous extracts of the plant we deemed it proper to extract it with some other solvents. The present investigation has revealed the presence of a colourless crystalline principle, for which the name 'arjunin' is suggested (0·2%) from the benzene extract of the plant.

Arjunin is acidic in nature since it dissolves with effervescence in dilute sodium bi-carbonate solution, and gives a faint red colour with litmus. On continuous boiling with sodium bi-carbonate an insoluble sodium salt is thrown down. It also forms a deep green colour with ferric chloride, forms di-acetyl and di-benzoyl derivatives an hence contains two phenolic hydroxy groups. A penta-nitro-derivative has also been prepared.

Probably Arjunin is the aglucone of a glucoside present in the plant claimed to have been isolated by Ghoshal from the benzene extract, and which hydrolyses in the process of isolation.

EXPERIMENTAL

An authentic sample of the bark was collected from the neighbourhood of Allahabad in the months of January and February. It was dried in the sun for about a week whereby it lost about 40% of moisture. The dried bark was then finely crushed in an iron mortar, whereby a greyish, brown powder was obtained. On complete ignition of the bark in a porcelain dish, there was left about 28·9% of a dirty white ash. The following elements or radicals were detected in the ash :—

Potassium, sodium (traces), aluminium, calcium, magnesium (traces), silica, carbonates, phosphates, chlorides and sulphates.

In order to get an idea about the solouble portions of the drug 20 grams of the powdered stuff was successively extracted in a Soxhlet's extraction apparatus using different solvents when the following amounts of extract dried at 100 were obtained.

Benzene Extract:—4·10%. An yellowish green extract containing some solid stuff suspended in it. It gave a green colouration with ferric chloride; reduced Fehling's solution

readily, and gave a lead salt with lead acetate. No reactions for alkaloids were obtained.

Chloroform Extract:—1·00%.—A pale yellow coloured extract was obtained, containing nothing of much interest. No reactions for alkaloids were obtained.

Ethyl Acetate Extract:—3·2%. A light brown coloured extract was obtained containing a dirty white stuff crystallising from it. The extract gave a lead salt with lead acetate, and a light green colour with ferric chloride. The crystalline stuff on recrystallisation melted at 174°C.

Aqueous Extract:—13·21%. A dark red coloured extract consisting mostly of tannins, sugars and colouring matters.

For a complete analysis 6 kilograms of the powdered bark was exhaustively extracted with benzene in a big extraction flask of 5 litre capacity. The extract which was of a pale greenish yellow colour was collected together and the solvent removed by distillation. On cooling the concentrated extract a brownish white sediment (15 gms.) separated which was filtered and washed till a dirty white stuff was obtained. This was dried in a steam oven and powdered. It melted at 180-182°C. It was next refluxed thoroughly with a large volume of petroleum ether, in order to free it from any oily or waxy material. The petroleum ether extract on concentration deposited a *dirty* white substance in waxy flakes melting at 60-62°C. which was identified to be a wax. The quantity obtained however was very small (0·8 g.) to permit any purification or detailed investigation.

The wax-free arjunin was then dried thoroughly in a vacuum dessicator over fused calcium chloride, and recrystallised from a large volume of benzene when microscopic needles were obtained melting sharp at 192°C. (decomp.). It could also be crystallised from glacial acetic acid. The recrystallised product (12·4 gms.) was then dried in a steam oven.

Properties of Arjunin:—Arjunin is a colourless crystalline substance having no taste or odour. It is slightly soluble in hot water. In ethyl alcohol, methyl alcohol, pyridine and glacial acetic acid it is readily soluble and less so in acetone, benzene, chloroform and amyl alcohol. In ethyl acetate, petroleum ether, ether and carbontetrachloride it is insoluble. With concentrated sulphuric acid a light yellow colouration is obtained which changes to blood-red on warming and deep violet on standing. With concentrated nitric acid a light red colouration is obtained which on warming evolves fumes of nitric oxide. With chloroform, acetic anhydride and sulphuric acid it gives a blood-red colouration. A violet colour is developed with Kellar-Kiliani reaction. It gives a green colour with alcoholic ferric chloride. With alcoholic lead acetate no precipitate is formed, but with basic lead acetate a heavy light yellow flocculant precipitate of the lead salt is thrown down. With silver nitrate it gives a white precipitate. It dissolves in alkalies and is probably decomposed on being boiled with it. In a dilute solution of sodium bi-carbonate it dissolves with much effervescence and on being boiled deposits the sodium salt as a white gelatinous mass.

(Found: C 59·80, 59·65; H 6·51, 6·30 M.W. (ebbullioscopic in alcohol) 499, 524, 508; (lead salt) 522; $C_{26}H_{32}O_{11}$ requires C 60·0; H 6·2 M.W. 520.)

A sample of arjunin has been sent to the Pharmacological Department of the King George's Medical College, Lucknow, where a detailed study of its physiological properties will be undertaken.

The Lead Salt:—(1 g.) Arjunin was dissolved in 50% ethyl alcohol and an aqueous solution of basic lead acetate added drop by drop till in excess. The flocculant pale yellow precipitate of the lead salt was formed which was filtered on a pump and washed till free of lead and dried. It was a pale yellow

amorphous brittle mass. (Found: Pb 44·1% $C_{26}H_{28}O_{11}Pb_2$ requires Pb 44·5%.)

The Silver Salt:—(0·5 g.) Arjunin was dissolved in dilute alcohol and a concentrated aqueous solution of silver nitrate added gradually till the precipitate was no longer formed. The flocculant white silver salt formed was filtered, washed free of silver and dried. It was dirty greyish white in appearance. (Found: Ag. 46·1% $C_{26}H_{28}O_{11}Ag_4$ requires Ag. 45·5%).

The Sodium Salt:—Arjunin (0·5 g.) was dissolved in an aqueous solution of sodium bi-carbonate. Great amount of effervescence took place and the stuff went into solution. On further warming it in a water-bath, the sodium salt was thrown down as a brown gelatinous mass. It could not, however, be obtained in a state of sufficient purity for analysis.

Di-acetyl arjunin:—1 g. arjunin, 50 cc. of acetic anhydride and a little fused sodium acetate were refluxed over a sand bath for about four hours. The melt on cooling was added into a large volume of water, when the acetyl derivative separated as an amorphous mass. It was filtered, washed thoroughly and dried in vacuum over fused calcium chloride. On crystallisation from alcohol, small flakes were obtained melting at 103°C. (Found: C 59·15; H 6·00 $C_{30}H_{36}O_{13}$ C 59·61; H 5·96%.)

Di-benzoyl arjunin:—Arjunin (1 g.) was dissolved in (50 cc.) pyridine and benzoyl chloride (10cc. 0) added gradually with constant shaking. When the whole of benzoyl chloride had been added the mixture was rapidly shaken for about two hours. It was then poured in water whereby an oil separated at the top. This oil on keeping under water for a long time solidified to a hard vitreous mass. On crystallisation from ethyl alcohol well defined small needles were obtained melting at 207° C. (Found: C 65·5 H 5·65 $C_{40}H_{40}O_{13}$ requires C 65·8 H 5·49%.)

Penta-nitro arjunin :—Arjunin (0·8) was dissolved in warm concentrated nitric acid (Sp. gr. 1·08) with gradual stirring. When the solution was complete it was refluxed over a sand bath for half an hour. Copious fumes of nitric oxide were evolved and a gelatinous sticky mass separated. On cooling the mixture and repeatedly washing it with hot distilled water the nitro derivative was obtained as an orange coloured brittle mass. It was then crystallised from glacial acetic acid, whereby pale yellow plates were obtained melting sharp at 118° C. (Found: N 9·62 $C_{26}H_{27}O_{21}N_5$ requires N 9·4%.)

Further work on this plant is in progress.

ACKNOWLEDGEMENT

One of us (R. R. A.) is highly indebted to the Kanta Prasad Research Trust of the Allahabad University for a scholarship which enabled him to investigate this problem.

SUMMARY

From the benzene extract of the bark of *Terminalia arjuna* Bedd, an acidic principle has been isolated called 'arjunin' m.p. 192°C $C_{26}H_{32}O_{11}$; the lead, silver and sodium salts, the di-acetyl, di-benzoyl and penta-nitro derivatives have been prepared.

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CHEMICAL EXAMINATION OF *CUSCUTA REFLEXA*—ROXB.
PART I—THE CONSTITUENTS

BY

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INTRODUCTORY

Cuscuta reflexa Roxb known as *Amarvel* or *Akashbel* in Hindustani and *Swarnalata* in Bengali is common golden yellow dodder-like parasite belonging to the natural order Convolvulaceæ. It is common throughout India growing on thorny or other shrubs.

As regards its medicinal properties Mohammedan writers consider it to be alterative and depurative, a purge for bile and black bile useful in effections of the brain such as fits, melancholy, insanity, etc. (Dymock: *Pharmacographica Indica*, 1890, 11, 548). It is also supposed to be purgative and used externally against itch; and internally in protracted fevers, retention of wind, and induration of the liver. (Kirtikar and Basu: *Ind. Med. Plants*, 1918, 11, 888).

Very little is known regarding the chemical composition of *Cuscuta reflexa*, though Barbey in 1895 [*Jour. Pharm*., 1895, (6) 2, 107—112] working on another variety *C. epithymum*, isolated from it an yellow amorphous colouring matter by precipitation from the alkaline extract with dilute sulphuric acid and subsequent extraction with ether. He termed his colouring principle cuscutin but gave no analytical data. He also isolated along with tannins and resinous substances a small amount of a crystalline substance having a faint odour of coumarin.

On account of the medicinal properties associated with *Cuscuta reflexa* in India and the uncertainty regarding its

chemical composition the present authors were tempted to put it to a more systematic chemical analysis. As a result of our investigations we have been able to isolate cuscutin the colouring matter of Barbey (*loc. cit.*) in a crystalline form (0·2%) along with a white crystalline substance having the properties of lactone, called by us cuscutalin (1·0%) a small amount of brown wax (0·1%) and large quantities of reducing sugars.

For the isolation of cuscutin we tried at first the method adopted by Barbey (*loc. cit.*), but the colouring matter obtained was non-fusible and could not be made to crystallise. We, therefore, worked with sun-dried material and could get the colouring matter in a crystalline form, from the aqueous solution of the alcoholic extract after the removal of cuscutalin as will be clear from the experimental portion of this paper.

Cuscutin is feebly acidic in properties since it dissolves in sodium-bi-carbonate solution with slight effervescence and can be precipitated unchanged by acids. It forms a di-acetyl, a di-carbethoxy and a di-methoxy derivatives and gives a very delicate violet green colour with ferric chloride; and hence contains two phenolic hydroxy groups. It does not form any oxime.

Cuscutalin is a lactone. It dissolves in caustic alkalies with a beautiful yellow colour. Although containing no aldehydic or ketonic groups reduces Tollen's reagent slowly and gives a reddish brown colouration with an alkaline solution of potassium nitroprusside. These reactions definitely prove it to be a member of the $\Delta^{\alpha\beta}$ lactones which have been adequately reviewed by Jacobs (*Jour. Bio. Chem.*, 1926, **67**, 333—339, *Phys. Rev.*, 1933, **13**, 222). However more work on the elucidation of its constitution is in progress and will be published shortly.

Pharmacologically cuscutalin appears to be a potent drug. It has been sent to King George's Medical College,

Lucknow, where a detailed study of its physiological properties will be undertaken.

EXPERIMENTAL

30 Kg of the fresh *Cuscuta reflexa*, was collected from the neighbourhood of Allahabad in the months of October and November, from various hosts. A preliminary examination showed that the chemical composition of the parasite was practically independent of the nature of its host. It was dried in sun and by so doing lost about 90% of moisture. It was then finely crushed in an iron mortar and when burnt in a porcelain dish left 9·85% of a brownish white ash. This ash consisted of 19·12% of water insoluble and 80·88% of water soluble inorganic material. The following elements and radicals were detected in the ash :—

Sodium, potassium, magnesium (traces), calcium, nitrates, phosphates, carbonates, and silica.

In order to get an idea about the soluble portions of the drug, samples of the finely crushed material were exhaustively extracted in a Soxhelt's apparatus using different solvents when the following amounts of extracts were obtained dried at 100°.

Petroleum Ether Extract:—15·2%. The extract was of a deep green colour, containing a greenish white crystalline matter suspended in it.

Chloroform Extract :—18·0%. The extract was of a pale yellow colour, and contained a small amount of a pale yellow deposit.

Alcoholic Extract :—22·5%. The colour of the extract was greenish yellow containing a large amount of crystalline matter. It reduced Fehling's solution easily. Gave a lead salt with neutral lead acetate, a silver salt with silver nitrate, deep greenish blue colour with ferric chloride. No reactions for alkaloids were obtained.

Aqueous Extract:—5·0%. The extract was of a light orange colour, reduced Fehling's solution readily and gave a deep green colour with ferric chloride.

For a complete analysis 2·5 kilograms of the powdered material was exhaustively extracted with boiling alcohol in a big extraction flask of five litre capacity, till the extract failed to give any white stuff on cooling. The extract which was of a light yellow colour was filtered hot and on cooling deposited cuscutalin which was filtered on a pump and washed with cold alcohol till a perfectly white stuff was obtained. In order to remove the whole crystalline mass from the plant at least five extractions were necessary. The stuff was dried in *vacuo* over calcium chloride and weighed 25 grams. The melting point was 64°C. It was recrystallised from methyl alcohol. At this stage a substance was left which will not go into solution even on prolonged boiling. It was yellowish brown in colour and melted at 74°C. From its properties it appears to be a wax. The quantity obtained was too small for any detailed investigation. Finally cuscutalin was recrystallised from a large volume of boiling ethyl alcohol, when perfectly white crystalline flakes were obtained melting sharp at 68°C.

Properties of Cusculation:—Cuscutalin is a colourless crystalline substance soluble in benzene, phenol, chloroform, ether and slightly so in ethyl alcohol, methyl alcohol, ethyl acetate, pyridine and acetic acid. It is insoluble in water. It dissolves in boiling caustic potash or caustic soda solution giving a beautiful yellow colouration. It decolourises a solution of bromine in chloroform and a dilute alkaline solution of potassium parmanganate. It gives a positive Salkowski's reaction, *i.e.*, a solution of cuscutalin in chloroform and concentrated sulphuric acid gives a red and finally a green colouration. If cuscutalin is dissolved in chloroform and a little acetic anhydride is added followed by Con. H_2SO_4 a green colouration is formed

which finally changes to blue. It dissolves in concentrated sulphuric acid with a yellow colour which finally changes to deep red on warming, with concentrated hydro-chloric acid it gives no colouration, but with concentrated nitric acid a bright red colouration is developed on heating. It gives no precipitate with lead acetate or silver nitrate, but with alcoholic ferric chloride a light red colouration is produced. With Tollen's reagent a light yellow coloured solution is formed which slowly changes to brown and finally a gradual reduction takes place. With alkaline solution of potassium nitro-prusside it gave a reddish brown colouration. [Found: C 74·0; 74·3; H 3·5, 3·7; M.W. (cryoscopic in phenol) 260, 281; $C_{18}H_{10}O_4$ requires C. 74·5; H 3·4% M.W. 290.]

Isolation of Cuscutin:—The combined alcoholic extract after the removal of cuscutalin was concentrated when a thick syrupy liquid was obtained. It was greenish red in appearance and smelt mostly of sugars. This was then extracted successively with benzene, ethyl acetate and water.

The benzene extract was deep green in colour and contained a huge amount of chlorophyll. This was evaporated to dryness and the dried mass washed repeatedly with cold alcohol till a greyish white stuff was left. This was crystallised from boiling alcohol when white flakes of cuscutalin (m. p. 67-68°C.) were obtained.

The ethyl acetate extract was golden red in appearance and on concentration became very syrupy. Nothing chemically definite could be isolated from it.

After the treatment with benzene and ethyl acetate, the original mass was dissolved in ice-cold water with constant stirring. A brown stuff separated (m.p. 140°) which was filtered and washed. It was dissolved in a large quantity of water at the ordinary temperature and the golden yellow solution kept in an ice-chest overnight for crystallisation,

when pale yellow crystals separated which were filtered, washed and dried. The melting point was 208-209° (decomp.), with previous softening at 179°.

The aqueous extract after the removal of cuscutin as described above, was concentrated and was found to reduce Fehling's solution readily. It contained a huge amount of reducing sugars.

Properties of Cuscutin :—It is easily soluble in ethyl and methyl alcohols, pyridine and acetic acid, less so in acetone and water and insoluble in benzene, ethyl acetate, chloroform, ether and petroleum ether. The solution in all these solvents has an orange yellow colour. It decomposes if boiled with water. Cuscutin dissolves readily in solutions of alkali carbonates, bi-carbonates and hydroxides giving a bright orange yellow solution, which undergoes decomposition if boiled. It can, however, be precipitated from these solvents by the addition of dilute mineral acids. With concentrated sulphuric acid a reddish brown colouration is produced with a slight fluorescence, with Con. nitric acid a blood-red colouration is developed which changes to light orange on warming, in Con. hydro-chloric acid it dissolves with an orange yellow colouration. It produces a green precipitate with ferric chloride, an yellowish white precipitate with lead acetate and a white precipitate with silver nitrate. The dilute alkaline solution decolourises a solution of potassium permanganate. It gave a negative test for flavones and was completely decolourised on being boiled with ammonia and zinc dust. It was not glucosidic in character. [Found: C 53·4, 53·2; H 3·9, 3·7; M.W. (cryoscopic in phenol) 330, 342, (lead salt) 338; $C_{15}H_{12}O_9$ requires C 53·6; H 3·6% M. W. 336].

Lead Salt :—To 0·5 gm. of cuscutin dissolved in alcohol, an alcoholic solution of lead acetate was added drop by drop till the yellow precipitate was no longer obtained. The lead salt was filtered, washed thoroughly and dried. It was an

yellowish brown stuff. (Found : Pb 48·07 ; $C_{30}H_{18}O_{18}Pb_3$ requires Pb 48·2%).

Di-acetyl-cuscutin :—1 gram of cuscutin, 25cc. of acetic anhydride and a little fused sodium acetate were refluxed for two hours. The hot mass was then poured into water when the acetyl derivative separated. This was filtered off and crystallised from glacial acetic acid when yellowish brown micro-crystalline needles were obtained melting at 140°C. [Found : C 50·1 ; H 3·9 ; $C_{15}H_{10}O_9$ $(C_2H_3O)_2$ requires C 50·4, H 3·5%.]

Di-carbethoxy-cuscutin :—1 gram of cuscutin was dissolved in pyridine and to it an excess of ethyl chloroformate was slowly added with vigorous shaking till the solution had a slight pink colour. It was then poured into water, a black oil separated which solidified on keeping in water to a hard vitrous mass. It was filtered and crystallised from ethyl alcohol when brown crystalline flakes were obtained melting at 151°C. (decomp.). It dissolved in most organic solvents and gave no colouration with alkalies. (Found: C 52·9 ; H 3·9 ; $C_{15}H_{10}O_9-C_6H_{10}O_4$ requires C 52·5 ; H 4·2%.)

Di-methoxy-cuscutin :—0·8 gram of cuscutin were dissolved in strong caustic potash and di-methyl sulphate added slowly with constant shaking. More alkali was then added and the mixture shaked vigorously. It was cooled in tap-water. After about an hour of shaking an oily liquid separated at the top which gradually solidified on keeping in cold water. It was filtered and crystallised from alcohol when pale yellow crystalline flakes were obtained melting at 193°C. [Found: C=55·8, H=4·9; $C_{15}H_{10}O_9$ $(C.H_3)_2$ requires C=56·0 ; H 4·4%.]

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PUTREFACTIVE DECOMPOSITION OF BENGAL SILK COCOON

BY

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It is a well-known fact that silk cocoon in presence of water undergoes decomposition very quickly and in the silk industry during the process of maceration of the cocoons in aqueous liquids for the removal of the yarn, very often a heavy odour of putrefaction is evolved, particularly if the temperature of the atmosphere is high. The products of such putrefaction have never been investigated by any one up to this time and, although from the chemical point of view this would be quite interesting, yet the present investigation was undertaken from a slightly different standpoint. From a private communication from his friend Dr. V.N. Vyas of the King George's Medical College, Lucknow, the present author came to understand that the product of putrefaction of silk acted as a strong pressor substance for the heart, raising the blood pressure to a considerable extent. Apparently this must be due to the formation of some substances of great physiological activity during the process of putrefaction of silk cocoon, and this was a sufficiently interesting field for research. Consequently the present investigation was undertaken with a view to elucidate the constitution of the compounds formed during the putrefaction.

A large supply of pierced silk cocoons were obtained through the courtesy of the Sericulture Department of the Government of Bengal, Berhampore. A preliminary examination of the cocoons revealed the fact that they contained

25·6% of sericin, 70·4% of fibrin, 2·2% of moisture and about 2·0% of inorganic matter. The cocoons were coloured bright yellow and apparently contained a fairly large proportion of colouring matter in the form of carotin. Complete hydrolysis by hydrochloric and subsequent estimation of the amino acids by the Fischer's ester method gave the following results, which can be compared with the results obtained by Abderhalden and Brahm (*Ber*, 1909, **61,** 256) by the hydrolysis of Bengal silk as given in the table below:

	From Bengal silk cocoon by the present author	From Bengal silk by Abderhalden and Brahm
Glycin ...	... 28·4%	30·5%
Alanin ...	... 22·85	20·0
Serine ...	... 5·75	1·8
Leucine ...	... ·85	1·2
Aspartic acid	... Traces	·8
Glutamic acid	... ·8	Traces
Phenyl-alanine	... ·8	1·4
Proline	... Traces	1·0
Tyrosine ...	... 12·8	10·0

From the above table it will be apparent that the really great difference between the two sets of results lies in the comparatively large proportion of serine obtained from the silk cocoon by the present author.

The cocoons on maceration with about 50 times their weight of water and incubation at 37° for about a week, underwent extensive putrefaction and lost 35% of their weight during the process. The liquid expressed from the undecomposed fibres had a most nauseating odour, and on systematic working up as described in the experimental portion of the paper, yielded the following substances in the pure state in the form of their hydrochlorides: ammonia

methylamine, ethylamine, p-hydroxy-phenylethylamine and amino-ethanol (1·3%, 1·8%, ·8%, 2·1% and ·3% respectively). Carbondioxide was freely evolved during the process of putrefaction. From the afore-mentioned results it is quite apparent that the process of putrefaction of silk cocoon involved two stages, namely, one of hydrolysis of the protein matter into amino acids and the other of elimination of carbondioxide from the amino acids with formation of amines, the two processes following each other so closely that at no time any great concentration of amino acids can be detected in the putrefying material. The amines mentioned above being well-known pressor substances, particularly p-hydroxy-phenylethy-lamine or tyramine, there is little wonder now that a decoction of putrefied silk cocoon would act as a strong pressor substance for the heart. The fibrous matter left after the putrefaction was over was found to undergo very little change on further treatment in the same way, and was practically pure fibrin. It had almost the same lustre as ordinary silk fibre but only about half the strength. It was practically completely bleached after the putrefaction. It was not further examined chemically.

EXPERIMENTAL

100 grams of silk cocoons were macerated with 5 litres of distilled water and the mixture contained in a wide mouth extraction flask was incubated at 37° for seven days. At the end of that period the light brown cloudy liquid with a disgusting odour of putrefaction was squeezed off from the fibrous material and filtered first through cloth and then through filter paper. The filtrate which had a strongly alkaline reaction was neutralised with dilute hydrochloric acid and evaporated to dryness at first over the free flame and finally on the water-bath. A dark brown crystalline solid (yield 19·8%) was left behind and from a large number of experiments of the above type a total quantity of

268 grams was collected. This was refluxed with 3 litres of absolute alcohol and 30 grams of animal charcoal for nearly 12 hours and then filtered. The filtrate on cooling deposited a large amount of colourless crystalline needles which were filtered off, washed with absolute alcohol and dry ether and recrystallised from absolute alcohol. This product was termed *Fraction A.*

The residue on the filter paper was extracted with boiling water, and the filtered extract evaporated to a small volume and allowed to stand when a large amount of colourless feathery crystals separated out. This was filtered off and recrystallised from a small quantity of boiling water. This was termed *Fraction B.*

The mother liquor from Fraction A was evaporated to about 500 cc. in volume and allowed to stand in the refrigerator for 24 hours, when another crop of colourless needle-shaped crystals separated out. They were filtered off and recrystallised from pure methyl alcohol in colourless hygroscopic needles. This portion was termed *Fraction C.*

The mother liquor from the above was treated with dry ether until an oily precipitate was no longer formed. On allowing to stand in the refrigerator the oily product solidified and was filtered off and washed with dry ether. It was recrystallised from a mixture of equal volumes of dry ether and absolute alcohol in colourless prismatic needles. This was termed *Fraction D.*

The mother liquor and the washings from the above were collected together and the whole evaporated to dryness. A pale brownish white, highly hygroscopic crystalline solid was left behind which was washed with small quantities of petroleum ether and finally recrystallised from a mixture of equal proportions of chloroform and benzene. The substance was thus obtained in pale cream coloured highly hygroscopic needles. This was termed *Fraction E.*

EXAMINATION OF THE VARIOUS FRACTIONS MENTIONED ABOVE

Fraction A.—This melted at 269°C and was easily soluble in water. On treatment of the aqueous solution with dilute caustic soda or ammonia an immediate white precipitate was formed which was filtered off and crystallised from ether in colourless needles melting at 161°C. and identified to be *p-hydroxy-phenylethylamine* or *tyramine*. The melting point was unaltered on admixture with a genuine sample of tyramine obtained from Messrs. E. Merck. (Found : N = 10·4 ; $C_8H_{11}ON$ requires N = 10·2 %.)

Fraction B.—This did not melt at all but gradually sublimed on heating without leaving any residue. On treatment with caustic soda a strong smell of ammonia was evolved. The substance was identified as *ammonium chloride.*

Fraction C.—This melted at 223—224° and crystallised in two forms—needles and leaflets. On treatment with dilute caustic soda no precipitate was formed, but a strong ammoniacal fishy odour was evolved. Aqueous solution of the substance gave an immediate precipitate with aqueous picric acid which on recrystallisation from dilute alcohol melted at 206°. The substance was identified to be *methylamine hydrochloride* and the melting point was not depressed on admixture with a sample of the genuine substance obtained from Messrs. E. Merck. (Found : N = 20·5 ; CH_3NH_2. HCl requires N = 20·7 %.)

Fraction D.—This melted at 73—78° and crystallised both in the form of prismatic needles and also glistening leaflets. It was easily soluble in water and on treatment of the aqueous solution with dilute caustic soda no precipitate was formed, but a strong fishy odour was evolved. The aqueous solution gave immediate precipitates with dilute solutions of mercuric chloride, platinic chloride and chromic acid, but

not with aqueous picric acid. The crystalline substance on treatment with acetic anhydride and sodium acetate gave a crystalline acetyl derivative melting at 204°. The substance was identified to be *ethylamine hydrochloride* and was in all respects identical with a genuine sample of the substance prepared from Merck's 33% alcoholic ethylamine solution. The melting point was also not depressed on admixture with the prepared sample. (Found: N = 17·5; $C_2H_5NH_2$. HCl requires N = 17·1%.)

Fraction E.—This melted at 96 – 97° and was extremely hygroscopic. The aqueous solution was slightly acidic in reaction and gave immediate precipitates with aqueous platinic chloride and picric acid. The picrate crystallised from alcohol in large lemon-yellow hexagonal tablets melting at 158-159°. The substance was identified to be the ***hydrochloride of amino-ethanol*** and on account of the highly hygroscopic character of the hydrochloride, the picrate was analysed. (Found: N = 19·6; $C_2H_7NO. C_6H_3(NO_2)_3O$ requires N = 19·3%.)

The author wishes to express his best thanks to the Deputy Director of Sericulture, Government of Bengal, Berhampore, for a generous supply of pierced silk cocoons.

DYES DERIVED FROM ACETYLENE-DICARBOXYLIC ACID

BY

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In the light of 'a theory of colour on the basis of molecular strain' advanced by one of the present authors (Dutt, *J.*, 1926, **129,** 1171; *Jour. Ind. Chem. Soc.*, 1927, **IV**, 99), substances containing acetylenic linkages should produce greater absorption of light in the higher wavelengths and consequently should be more coloured than those containing ethylenic linkages by virtue of the former possessing triple bonds in place of the double bonds of the latter. A comparison of the absorption maxima of some well-known ethylenic and acetylenic compounds brings out this fact very clearly. Thus:

Name of the compound	Absorption maxima	Name of the compound	Absorption maxima
Ethylene ...	2440	Elaidic acid ...	2500
Acetylene ..	2470	Stearolic acid ...	2640
Styrene ...	2730	Diphenyl-diethylene	3400
Phenyl-acetylene ...	2740	Diphenyl-diacetylene	3630
Cinnamic acid ...	2800	Diiodo-ethylene ...	2860
Phenyl-propiolic acid	2820	Diiodo-acetylene ...	2940
Stilbene ...	2860		
Tolane ...	3030		

All the compounds mentioned above being colourless, their absorption bands lie in the ultra-violet region of the spectrum. Consequently their determination is a matter of

considerable difficulty, and their position is also found to change slightly with change in conditions and solvents in which they are examined. On account of this it was thought that if some dyestuffs could be prepared containing acetylenic linkages in their molecules, they could be easily compared with their ethylenic analogues by direct determination of their absorption spectra by means of a high dispersion glass spectrograph either by eye observation or by photographic methods. Selection of an appropriate starting material was not particularly easy on account of the great paucity of data available in literature with regard to acetylenic compounds, but after a considerable amount of deliberation and trial, acetylene-dicarboxylic acid was selected for this purpose.

Acetylene-dicarboxylic acid is very unstable in the ordinary sense, since when heated to its temperature of fusion, *i.e.*, 178°, it loses carbon dioxide progressively and gets converted first into propargylic acid and finally into acetylene:

$$\begin{array}{c} C\,COOH \\ ||| \\ C\,COOH \end{array} \xrightarrow{-CO_2} \begin{array}{l} CH \\ ||| \\ C-COOH \end{array} \xrightarrow{-CO_2} \begin{array}{c} CH \\ ||| \\ CH \end{array}$$

It does not give any anhydride under ordinary conditions, since most of the inorganic dehydrating agents like sulphuric acid, zinc chloride, hydrogen chloride, etc., employed for the production of anhydrides from dibasic acids, decompose it into carbon-dioxide and propargylic acid. By heating with acetic anhydride, the acid gets converted into acetoxy-maleic anhydride:

$$\begin{array}{l} C-COOH \\ ||| \\ C-COOH \end{array} \xrightarrow[\text{anhydride}]{\text{acetic}} \begin{array}{r} CH_3COO-C-CO \\ \| \quad\ >O \\ HC-CO \end{array}$$

Acetyl-chloride also gives the same product under identical conditions.

Since the acid does not form an anhydride under the usual conditions, it was at first thought that the production

of the pyronine dyestuffs from the acid, which require the intermediate formation of the anhydride, would not be feasible, but as the result of trial experiments that were conducted, it was found that pyronine dyestuffs are quite readily formed from acetylene-dicarboxylic acid by condensation with aromatic amino and hydroxy compounds in the normal manner. Consequently the only hypothesis that can be advanced to explain this interesting phenomenon is that acetylene-dicarboxylic acid does form an anhydride like maleic and succinic acids, but under ordinary conditions, the anhydride is very unstable and undergoes decomposition as soon as it is formed. If however substances are simultaneously present with which the anhydride can undergo condensation, it reacts with them as soon as it is formed with production of stable condensation products.

By analogy with dyes derived from citraconic acid (Dhar and Dutt, *Jour. Ind. Chem. Soc.*, 1927, IV, 254) it is quite reasonable to suppose that dyes derived from acetylene-dicarboxylic acid also possess the same skeleton structure with the exception that the latter possess a triple bond in place of the double bond of the former. Consequently it can be expected that dyes derived from acetylene-dicarboxylic acid will be more coloured than the corresponding dyes derived from citraconic acid. This expectation with regard to these dyestuffs has been realised and on systematic comparison it has been found that they are more coloured and more absorptive than the corresponding dyes derived from citraconic, itaconic or maleic acid. This will be quite evident from the tables of absorption maxima given at the end of the paper.

The following aromatic amino and hydroxy compounds have been condensed with acetylene-dicarboxylic acid and the corresponding dyestuffs obtained: phenol, resorcinol, phloroglucinol, orcinol, m-dimethylamidophenol, m-diethylamidophenol and m-phenylenediamine. The compound with

resorcinol has also been brominated and the corresponding tetrabromo derivative prepared. The triple bond has been found to be unattacked during the process.

Condensation was not found to take place in the following cases: o-, and p-cresol, o-, m-, and p-xylenols and m-amidophenol. In the case of catechol and pyrogallol, although condensation had apparently occurred, yet the products could not be obtained in a state of sufficient purity for further examination or analysis.

Although condensations took place without the use of any condensing agent, yet the employment of a trace of concentrated sulphuric acid and in some cases, tin tetrachloride, was found to be beneficial in producing greater yield of the dyestuffs. Nevertheless it was found however that the yields obtained were very unsatisfactory on account of the formation of tarry by-products, and a considerable loss of the starting materials occurred during the condensation process. With the exception of the phenol compound, all the rest of the dyestuffs are strongly fluorescent in solution.

EXPERIMENTAL

Phenol-acetylenein.—A mixture of acetylene-dicarboxylic acid (2·1 g.), phenol (6 g.) and tin tetrachloride (15 g.) was heated in an oil-bath at 110—120° for 15 hours. The melt on cooling was poured into water and the excess of phenol distilled off in steam. The residue was extracted with concentrated ammonia and precipitated with hydrochloric acid and the process repeated a number of times. The brown product thus obtained was finally purified by extraction with ether and crystallisation from the same solvent. It is a brownish yellow microcrystalline substance which shrinks at 115° and melts with decomposition at 119-120°.

The substance is readily soluble in alcohol to a pink solution. In acetone, glacial acetic acid and ether a bright

yellow solution is obtained. It is insoluble in water, chloroform, ligroin, benzene, petroleum ether and carbondisulphide. In dilute alkalies it dissolves with a brilliant pink colour and from the solution it is reprecipitated unchanged by acidification. (Found: C=72·05; H=3·82; $C_{16}H_{10}O_4$ requires C=72·18; H=3·76%.)

Resorcinol-acetylenein.—A mixture of acetylene-dicarboxylic acid (1·5 g.), resorcinol (4 g.) and two drops of concentrated sulphuric acid was heated in an oil-bath at 120—130° for 8 hours. The reaction product was then dissolved in 5% cold caustic soda solution and after filtration it was reprecipitated with dilute hydrochloric acid. It was then dissolved in absolute alcohol and precipitated by dry ether. Finally it was crystallised from absolute alcohol in brown microscopic needles which decomposed at 185°.

The substance dissolves in alcohol, acetone, acetic acid and pyridine forming bright yellow solutions with intense green fluorescence. In dilute caustic alkalies it dissolves with an orange colour and the same bright green fluorescence. (Found: C=67·67; H=3·83; $C_{16}H_8O_5$ requires C=67·77; H=3·86%.)

Tetrabromoresorcinol-acetylenein—The above compound (·8 g.) dissolved in alcohol (40 c.c.) was treated with an excess of bromine in the same solvent and the mixture heated under reflux on the water-bath for three hours. On the addition of water a dark brown heavy liquid was precipitated which was separated by decantation and washed with mixed solutions of potassium iodide and sodium thiosulphate, in order to remove the excess of bromine still present. On treatment of the heavy liquid with cold 2% caustic soda, the greater portion of it dissolved forming a bright pink solution, while a small oily residue remained. The latter on examination was found to be bromoform and the pink solution on treatment with dilute hydrochloric acid precipitated the colouring matter in brick-red flocks which

were collected and crystallised from glacial acetic acid in steel-blue needles with a golden metallic lustre. It melts at 115—117° with decomposition. (Found: Br=53·46; $C_{16}H_6O_5Br_4$ requires Br=53·51%.)

Phloroglucinol-acetylenein.—This was obtained from phloroglucinol and acetylene-dicarboxylic acid in accordance with the method described above. The substance crystallises from absolute alcohol in brown microscopic needles which do not melt even at 310°. It dissolves in most of the organic solvents and also dilute alkalies with a yellowish pink colour. (Found: C=57·72; H=3·77; $C_{16}H_8O_7, H_2O$ requires C=58·09; H=3·03%.)

Orcinol-acetylenein.—This was obtained from orcinol and acetylene-dicarboxylic acid in a similar way to the above. It is a light yellow amorphous powder which melts with decomposition at 155—157° and dissolves in most of the organic solvents with a yellow colour and in dilute alkalies with a bright pink colour. The solution in each case has a dark green fluorescence. (Found: C=69·96; H=4·08; $C_{18}H_{12}O_5$ requires C=70·13; H=3·96%.)

m-Dimethylamidophenol-acetylenein.—A mixture of acetylene-dicarboxylic acid (2·5 g.), m-dimethylamidophenol (6 g.) and 4 drops of concentrated sulphuric acid was heated in an oil-bath at 130—140° for 8 hours. The cold melt was extracted with dilute hydrochloric acid and the filtered extract precipitated with dilute sodium carbonate. The pink coloured flocculent mass was filtered off and crystallised from 80% alcohol in fine pink needles, melting with decomposition at 126°.

The substance is easily soluble in alcohol and acetone, giving pink solutions with strong orange-brown fluorescence. In dilute acids also the same colour and fluorescence are observed. It is moderately soluble in chloroform, pyridine and ethylacetate but dissolves only slightly in carbondisulphide and ether. It is completely insoluble in water, benzene

and petroleum ether. (Found: N = 8·61; $C_{20}H_{18}N_2O_3$ requires N = 8·36%.)

m-Diethylamidophenol-acetylenein.—This was prepared from acetylene-dicarboxylic acid and m-diethylamidophenol in a similar way to the above. It is a pink substance melting with decomposition at 109° and with properties very similar to the above-mentioned compound. (Found: N = 7·39; $C_{24}H_{26}O_3N_2$ requires N = 7·18%.)

m-Phenylenediamine-acetylenein.—A mixture of acetylene-dicarboxylic acid (2 g.) and m-phenylenediamine hydrochloride (4·5 g.) was rapidly melted over a free flame and quickly cooled, the whole operation hardly taking more than two minutes. The dark red melt was extracted with absolute alcohol and filtered from the unchanged diamine hydrochloride. The addition of ether to the above filtrate precipitated the dyestuff in bright yellow flocks which were collected and crystallised from 90% alcohol in light brown microscopic needles which decompose without melting at 260°.

The substance is fairly soluble in alcohol, acetone, acetic acid and pyridine, slightly soluble in ethylacetate, chloroform and water and completely insoluble in ether, benzene, carbondisulphide, ligroin and petroleum ether. (Found: N = 15·54; $C_{16}H_{11}N_3O_2$ requires N = 15·17%.)

Absorption maxima of the acetyleneins and their analogues.

Compound	Acetylenein	Malein	Citraconein	Itaconein.
Phenol ...	5210	...	...	...
Resorcinol ...	5180	4890	4940	4880
Tetrabromo-resorcinol ...	5600	5180	5490	...
m-diethyamido-phenol ...	5670	5400	5560	5470
Phloroglucinol...	5640	...	...	...

DYES DERIVED FROM ACRIDIC ACID

BY

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Acridic acid, which is quinoline-2 : 3-dicarboxylic acid, contains two carboxyl groups in ortho position to one another, and is therefore expected to yield dyestuffs on condensation with aromatic amino and hydroxy compounds in the same way as phthalic acid or quinolinic acid (Ghosh, J., 1919, **115**, 1102). Recently, Tewari and Dutt (*Jour. Ind. Chem. Soc.*, 1928, **V**, 58) have successfully condensed quinoline-1 : 2 : 3-tricarboxylic acid with aromatic amino and hydroxy compounds with production of dyestuffs having interesting properties of colour and fluorescence. They could not condense acridic acid itself on account of the fact that at that time it was practically an inaccessible material, but nevertheless from theoretical considerations they came to the conclusion that dyes derived from acridic acid, even if they could be prepared, would have the same colour as the corresponding dyes derived from quinoline-1 : 2 : 3-tricarboxylic acid.

Acridine being now available in quantity, acridic acid was prepared from it by oxidation with potassium permanganate, and the acid condensed with aromatic amino and hydroxy compounds in the usual manner with production of dyestuffs. These on comparison with the corresponding dyes derived from quinoline-1 : 2 : 3-tricarboxylic acid prepared by Tewari and Dutt, it was found that the former class of dyestuffs are much more intensely coloured and far more absorptive than the latter. From this it is quite

evident that the extra carboxyl in the dyes derived from quinoline-1 : 2 : 3-tricarboxylic acid acts as a bathochrome in reducing the intensity of colour and fluorescence. This fact will be quite apparent from the table of absorption maxima given at the end of the paper.

The following aromatic amino and hydroxy compounds have been condensed with acridic acid and the corresponding dyestuff obtained: phenol, resorcinol, phloroglucinol, hydroxyquinol, m-aminophenol, m-dimethylamidophenol, m-diethylamidophenol, orcinol and m-phenylenediamine. The compound with resorcinol has also been brominated and the corresponding tetrabromo derivative obtained. The condensation takes place without the use of any condensing agent, but the addition of a trace of concentrated sulphuric acid is beneficial in producing an increased yield of the dyestuff. In general properties these dyes resemble the corresponding phthaleins, but the intensity of colour is slightly more and the fluorescence slightly less. They dye wool and silk beautiful and brilliant shades.

EXPERIMENTAL

Preparation of acridic acid.—Ten grams of acridine were brought to a fine state of subdivision by solution in dilute hydrochloric acid and precipitation with cold dilute caustic soda. The voluminous precipitate thus obtained was collected, suspended in water and oxidised with a 2% solution of potassium permanganate in the usual manner. The mixture was heated to boiling and the permanganate added until it was no longer decolorised. The precipitated manganese dioxide was filtered off, first through cloth and then through paper, and the filtrate after being neutralised with hydrochloric acid was evaporated to a small volume and allowed to stand when a large amount of potassium chloride crystallised out. The filtrate on acidification with concentrated hydrochloric acid deposited the acidic acid

gradually in crystalline crusts which were collected and recrystallised from dilute alcohol in stout prisms melting at 128—130° with decomposition.

The condensations of acridic acid with aromatic amino and hydroxy compounds were effected in the same manner as in the case of quinoline-1 : 2 : 3-tricarboxylic acid. For the sake of abbreviation, the results are given in tabular forms at the end of the paper.

Table I.

(A = — acridein)

Name	Appearance	M. P.	Colour in alcohol	Ditto with addition of acid or alkali	Shade on wool or silk	Analysis (theoretical values in brackets
Phenol-A ...	Yellow prisms	184°	Yellow	Crimson (Al)	...	C = 74·26 (74·8); H = 4·3 (4·0)
Resorcinol-A ...	Brown crystalline powder.	203°	Orange-yellow	Orange-red (Al)	Light orange	C = 71·82 (72·06); H = 3·36 (3·39)
Phloroglucinol-A	Brown yellow needles	above 280°	Orange-red	Blood-red (Al)	Light tan	N = 3·16 (3·38)
Hydroxyquinol-A	Brown powder	,, ,,	Brown-red	Violet-red (Al)	Light violet	N = 3·44 (3·38)
Orcinol-A ...	Dark-brown needles	,, ,,	Orange-yellow	Orange-red (Al)	Light brown	N = 3·15 (3·40)
M-Amidophenol-A	Yellow-brown prisms	280°—285°	Brown-yellow	Brown-red (Al)	Light chocolate	N = 10·82 (11·02)
M-Dimethylamidophenol-A	Pink needles	168°	Red	Crimson (Ac)	Bright pink	N = 10·13 (9·61)
M. Diethylamidophenol-A	,, ,,	120°	Dark red	Crimson (Ac)	Deep pink	N = 8·26 (8·72)
M-Phenylene diamine-A	Brown crusts	295°	Yellow	Orange (Ac)	Chestnut	N = 15·1 (14·73)
Tetrabromo resorcinol-A	Bright red prisms	above 290°	Bright pink	Crimson (Al)	Deep pink	Br = 45·22 (75·78)

Table II.

Absorption maxima of the acrideins and analogous dyestuffs (wavelengths).

Name	—phthalein	—quinolinein	—Cinchomeronein	—quinoline 1:2:3 tricarboxylein	—acridein
Phenol	5540	5560	5520	5560	5880
Resorcinol	4940	4950	4950	4930	5000
Phloroglucinol ..	4980	4990	4980	4930	5055
M-Diethylamidophenol...	5540	5540	5540	5540	5930
Tetrabromoresorcinol ...	5250	5250	5250	5180	5480

CHEMICAL EXAMINATION OF *BUTEA FRONDOSA* FLOWERS

Isolation of a Crystalline Glucoside of Butin

BY

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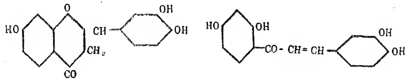
Butea Frondosa, called *Dhak* or *Polas* in Hindustani is a fine tree belonging to the natural order of Leguminosœ and is very common in India. The flowers which in the dried state are known as *tisu* or *palas-ke-phul* have either a bright yellow colour with bright orange spots or have an orange colour with red spots. They are the source of one of the few surviving members of the large number of natural organic colouring matters and are still used in India especially in the United Provinces. Large quantities of the flowers are collected in March and April and employed by the people to produce a yellow dye much used during the "Holi Festival." "The flowers are supposed to be astringent, depurative, diuretic, and aphrodisiac, as a poultice they are much used to disperse swelling and promote diuresis and the menstrual flow. They are given to enceinte women in the case of diarrhœa, and are applied externally in orchitis." (*Indian Medicinal Plants,* by K. R. Kirtikar and B. D. Basu, 1918, Part I, page 443.)

A preliminary examination of these flowers was made by Hummel and Caralls (*Proc.*, 1894, 10, 11) who isolated a substance termed "butein" $C_{15}H_{14}O_6$, and supposed this to be the true colouring matter. This product, in some respects yielded shades which were not unlike those of fisetin

obtained from young fustic. Hill (*Proc.*, 1903, 19, 133) extracted from these flowers a colouring matter in the form of lemon-yellow crystals which gave the reactions of fisetin. He noted further the presence of a phlobaphene which on fusion with caustic potash gave phloroglucinol and protocatechuic acid. Finally Hummel and A. G. Perkin, (1903, *Proc.*, p. 134) and Hummel and Perkin (*T.* 1904, 1463) examined the flowers and isolated by acid hydrolysis of the aqueous extract a colourless crystalline compound, butin $C_{15}H_{12}O_5$ melting at 224—226° and traces of an orange-red crystalline substance, butein $C_{15}H_{12}O_5$ melting at 213—215°. They also proved the nonoccurrence of fisetin in the flowers and were of opinion that they contain but a trace of free butin or butein. As a result of the dyeing tests with mordanted calico, they assumed that butin and butein were present in the form of glucosides which they failed to isolate.

The constitutions which Perkin and Hummel (*T.* 1904, 1463) assigned to butin and butein are those of 7 : 3′ : 4′ trihydroxy flavanone (I) and 2 : 4 : 3′ : 4′ tetrahydroxy-chalkone (II) respectively and they established the correctness of these formulæ by the synthesis of butin and butein trimethyl ether.



(I) (II)

Somewhat later (*Ber.*, 1911, 44, 3502) Göschker and Tambor prepared butein itself by treating protocatechuic aldehyde and resacetophenone in boiling alcohol with potassium hydroxide and found it to be identical in all respects with the natural product. Later on attempts of J. S. Shinoda,

S. Sato and M. Kawagoe (*J. Pharm. Soc.*, Japan, 1929, 49, No. 571, 123—125 and 1930, *Abst.* 93) to repeat their synthesis were unsuccessful. They however succeeded in synthesising butein by the condensation of the acid chloride of dicarbethoxy caffeic acid with resorcinol.

In view of the uncertainty as regards the probable existence of a glucoside in the flowers the present authors undertook a critical investigation and have isolated a colourless crystalline glucoside $C_{27}H_{32}O_{15}$, $2H_2O$ melting sharp at 193·5° and giving on hydrolysis two molecules of glucose and one of butin. A satisfactory process for the isolation of the diglucoside of butin, the first recognised member of the flavanone group has been worked out. The glucoside has been termed *butrin* in view of the fact that it is a glucoside of butin. The yield of butrin is on the whole 2·6% and that of the phlobaphene and of butein isolated are 1% and ·003% respectively.

EXPERIMENTAL

Dried flowers were obtained from the local market and their petals were collected and ground to a coarse powder in a grounding machine. The powdered flower-petals were extracted in 50 gram lots in a Sohxlet's apparatus with various organic solvents. The solvent was subsequently evaporated and the extract thus obtained dried to a constant weight at 100°C. The results are given below :—

Alcoholic extract.—(21·46%.) Orange-yellow, soft crystalline mass with a peculiar odour. It gives an olive-green colour with ferric chloride, a brownish-yellow granular precipitate with lead acetate and reduces Fehling's solution. Microscopic examination of the substance revealed the presence of a yellow crystalline colouring matter, a colourless crystalline substance, a wax and chlorophyll.

Acetone extract.—(13·56%.) Similar to the alcoholic extract, but much lighter in colour. A lemon-yellow crystalline substance could be easily discerned through the matrix of sticky matter.

Ethylacetate extract.—(5·5%.) Light yellow semi-solid substance, containing crystalline matter in suspension. It had properties similar to the alcoholic extract.

Benzene extract.—(·01%.) Light yellow substance with properties similar to the above.

The dried flowers when completely incinerated left 11·52% of a flesh coloured ash containing 2·98% of water soluble and 8·54% of water insoluble inorganic constitutents. The water soluble portion was mainly potassium carbonate with traces of sodium phosphate and chloride. The water insoluble portion contained calcium, magnesium, aluminium and traces of zinc together with sulphate, phosphate and carbonate.

Isolation of butrin.—For complete examination 4 Kgs. of the coarsely powdered flowers were in lots of 700 gms. repeatedly extracted with rectified spirit in a five litre extraction flask until the extract was no longer coloured. The combined orange-yellow extracts were distilled until most of the solvent had been recovered and the residue boiled frothily. It was then allowed to stand at the ordinary temperature for about a week by which time a large amount of soft crystalline matter had separated out. The thick crystalline magma was slightly thinned by the addition of about one-tenth of its volume of alcohol and filtered at the pump with good suction. The residue was washed with alcohol, until it had assumed a lemon yellow colour. After drying at first in the air and then in the steam-oven it was obtained as a yellow crystalline gritty mass melting at 135—139° and was of a glucosidal nature. It was repeatedly extracted with hot benzene in order to remove chlorophyll and waxy matter. Then it dissolved fairly readily in cold water and

this rather unusual property suggested that it was probably a salt of the dyestuff and on examination it proved to be the case since it contained potassium in organic combination in considerable quantity. By repeated crystallizations from alcohol it could only be obtained as a soft yellow crystalline mass containing in between clusters of white tiny needles. The substance on repeated extractions with boiling acetone gave a very small amount of an intensely sweet substance which was not further examined. The melting point of the substance rose to 190° after three crystallizations from hot water when it was obtained in the form of tiny colourless needles and after two crystallizations from alcohol melting point rose to 193·5° and did not rise any further. This substance on slow and careful crystallization is obtained in the form of glistening needles, often as long as one cm. The air-dried substance has the composition $C_{27}H_{32}O_{15}$, $2H_2O$ and loses the two molecules of water of crystallization when heated at 120°C for 15 hours. The anhydrous substance is extremely hygroscopic and readily absorbs two molecules of water of crystallization when exposed to air. It has all the properties of a glucoside since it reduces Fehling's solution only after hydrolysis with mineral acids. Further crops of the lemon-yellow gritty mass were obtained by concentrating the successive mother liquors and the aqueous washings but they required after removal of waxy matter and chlorophyll, several crystallizations from hot water before they were sufficiently pure to be crystallized finally from alcohol.

It is slightly soluble in cold water to a perfectly colourless solution which remains undecomposed on boiling. It is insoluble in acetone, ether, benzene, bromoform, carbontetrachloride, chloroform and petroleum ether; slightly soluble in cold and moderately soluble in hot ethyl and methyl alcohol, and glacial acetic acid and is very readily soluble in pyridine to colourless solution. In caustic alkalies and alkali

carbonates however it dissolves to a deep yellow solution and on boiling it undergoes decomposition giving a deep orange solution. It gives no precipitate in alcoholic solution with silver nitrate and calcium chloride, but gives a pale yellow precipitate with lead acetate. It does not give any coloration with alcoholic ferric chloride, but with excess of methyl or ethyl alcoholic hydrochloric acid and magnesium powder gives an intense violet coloration which turns brown on dilution with water, thereby showing that the substance is a flavanone derivative (Tsujimura, *Bull. Inst. Phys. Chem. Res.*, Tokyo, Vol. VI, 12, III; Chika Kuroda, J. C. S., 1930, **137**, 753). It gives an intense red coloration with concentrated hydrochloric acid which disappears on dilution. With concentrated sulphuric acid it first turns orange-red and finally dissolves to an orange-red solution which turns deep red on warming. It does not contain any methoxy or ethoxy groups since Zeisel's method of treatment gave a negative result. (Found: loss of H_2O at $120° = 5{\cdot}84\%$, $5{\cdot}79\%$; $C_{27}H_{32}O_{15}, 2H_2O$ requires $H_2O = 5{\cdot}69\%$. The air-dried substance gave on combustion $C = 51{\cdot}24$, $51{\cdot}26$, $51{\cdot}21\%$; $H = 5{\cdot}69$, $5{\cdot}84$, $5{\cdot}78\%$ and the fully dried substance gave $C = 54{\cdot}32$, $54{\cdot}19\%$; $H = 5{\cdot}67$, $5{\cdot}64\%$; $C_{27}H_{32}O_{15}, 2H_2O$ requires $C = 51{\cdot}26$; $H = 5{\cdot}69$; and $C_{27}H_{32}O_{15}$ requires $C = 54{\cdot}3$; $H = 5{\cdot}6\%$.)

Isolation of butein.—A portion of the filtrate after the separation of the above-mentioned butrin was treated with excess of hot alcoholic lead acetate and the resulting bright orange-yellow precipitate filtered off, and well washed first with alcohol and then with hot water. This on decomposition with hydrogen sulphide in alcoholic suspension and after filtering of the lead sulphide gave a deep orange solution which on concentration deposited no crystalline mass. It was treated with hot water when a viscous deep-red mass separated and the later on repeated extraction with water left behind a phlobaphene melting at 115°C which was also isolated by Hill.

The aqueous solutions after concentration at first under ordinary pressure and then under reduced pressure slowly deposited a small amount of an orange precipitate, which on repeated crystallization from dilute alcohol was obtained in the form of bright yellow needles melting at 213—215°. It gave an olive brown coloration with alcoholic ferric chloride, a deep red precipitate with alcoholic lead acetate and dissolved in alkalis and alkali carbonates to a deep orange-red solution. It was identified to be butein of A.G. Perkin (*loc. cit.*) which he isolated in traces from the flowers of *Butea Frondosa.* (Found: substance dried at 160°C = 66·07, H = 4·57%; $C_{15}H_{12}O_5$ requires C = 66·17%; H = 4·41%).

The alcoholic filtrate and washings from the aforementioned lead acetate precipitate gave a bright yellow precipitate on treatment with excess of basic lead acetate. This on working up in accordance with the method described above gave an orange-yellow solution which on concentration deposited considerable quantity of yellow crystalline mass which on purification was found to be butrin. No other glucoside or substance of interest could be isolated from these mother liquors.

HYDROLYSIS OF BUTRIN AND FORMATION OF BUTIN

Butrin (2 grams) was hydrolysed by heating with dilute sulphuric acid (100 c.c. of 5%) under reflux on the water-bath for two hours. The substance gradually dissolved forming a light yellow solution, which on standing for several days deposited a quantity (·8 g.) of pale yellow needles. These on several re-crystallizations from alcohol were obtained as a practically colourless substance crystallizing in needles and melting at 224—225°. This was identified as the butin of A. G. Perkin. The substance dried at 140° gave the

following results on analysis: (Found: C = 66·07; H = 4·41; $C_{15}H_{12}O_5$ requires C = 66·27; H = 4·4%.)

The mother liquor left after the hydrolysis of butrin, reduced Fehling's solution strongly, and on treatment with phenylhydrazine gave an osazone which melted at 202° and was identical with phenylglucosazone. The sugar contained in butrin therefore must be glucose, and the former must be the di-glucoside of butin.

One of us (J. B. L.) wishes to express his indebtedness to the Kanta Prasad Research Trust of the Allahabad University for a scholarship which enabled him to take part in this investigation. Further work on this subject is in progress.

METALLIC URANIUM IN ORGANIC SYNTHESIS—PART I

BY

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Since the middle of the nineteenth century, various metals or metallic derivatives have been used in organic synthesis. The earliest among them was potassium, which was used by Frankland and Koble (Annalen, 1848, 65, 269) in 1848, in the vain hope of isolating free alkyl radicals from alkyl nitrites. The use of sodium came immediately after this and it was found to be a better reagent than potassium. Zinc was used by Frankland (Annalen, 1853, 85, 329) in 1853 and also by Frankland and Duppa (Annalen, 1863, 126, 109) ten years later on. The use of magnesium in organic synthesis was made a classical study by Grignard (*Comp. Rend.* 1900, 130, 1322) and silver was extensively used by Wislicenus. Copper was used by Sandmyer and Gatterman (Ber., 184, 17, 1633; 189, 23, 1218) but its great value as a synthetic reagent was established in a remarkable series of experiments by Ullmann. (Ber., 1091, 34, 2174; 1903, 36, 2383; 1904, 37, 853; 1905, 38, 729; 1906, 39, 1691, 2211). Nickel was used as a catalytic hydrogenating agent by Sabatier and Sandereens (*Comp. Rend.*, 1901, 132, 201) and aluminium was used successfully by Roy and Dutt (*Jour. Indian Chem. Soc.*, 1928, 5, 103) and chromium by Chakrabarti and Dutt (*loc. cit.*, 1928, 5, 517). Very recently J. B. Lal and S. Dutt (*ibid.*, 1932, 9, 565) have used successfully a comparatively rare metal cerium in organic synthesis.

Uranium is not a common element and even as late as 1920 uranium metal was more or less a chemical curios.

Uranium in ores, the most important of which are pitchblende and carnotite is invariably associated with radium. Uranium metal may be prepared by several methods, such as reduction of uranium chloride UCl_4 with sodium or potassium, reduction of U_3O_8 with charcoal or coke in an electric furnace, reduction of uranium di- and tri-oxide (UO_2 and UO_3) by means of aluminium metal or by electrolysis of fused sodium-uranium chloride in an atmosphere of hydrogen. Commercial manufacture of uranium is comparatively of recent origin. Due to uranium metal being a by-product in the extraction of radium from ores and partly due to the great improvements in the thermite process of metal manufacture metallic uranium is now easily available, and particularly in view of the fact that it is a radioactive element, the present investigation was undertaken. Pure uranium is white, but the metal frequently has a yellow colour due to the presence of sodium nitride. The metal prepared by electrolysis is deposited as small shining crystals. Other methods of preparation gives either a black powder or a white compact mass. Uranium metal used in the present investigation was in the form of black dust and was evidently not very pure.

Uranium has not given very encouraging results in Ullmann's reaction but has proved highly satisfactory in Friedel-Craft's, Reformatsky's and Zincke's reaction. The action of benzylchloride on benzene, anisol, phenetol, and hydroquinone dimethyl ether in presence of uranium has been successfully tried and the products insolated in good yield. Attempts have been made to isolate and study the higher products formed in these reactions, for instance, in the case of benzene and benzylchloride besides pure diphenylmethane isolated in 40% yield, sym.-triphenylethane,

$$\begin{array}{c} C_6H_5.\ CH.\ C_6H_5 \\ | \\ CH_2\ C_6H_5 \end{array}$$

and o -and p-dibenzyl benzenes, and a trace of sulphur-yellow hydrocarbon m. p. 71° have been isolated. O- and p-dibenzyl benzenes were almost simultaneously prepared for the first time by Zincke (Ber., 1873, 6, 119) and Baeyer (*ibid.*, p. 220) the former of whom obtained them by the action of zinc on a mixture of benzene and benzyl chloride and the latter by the condensation of methylal and benzene by means of sulphuric acid. Zincke's later work (Ber., 1876, 9, 31) led to their complete identification and of their oxidation products, the dibenzoyl benzenes. Radziewanowski's surmise (Ber., 1894, 27, 3237) that the dibenzyl benzenes are formed, not by the direct action of benzylchloride on benzene, but at the expense of diphenyl methane is correct as the yield of dibenzyl benzenes can be substantially improved only by replacing diphenylmethane for benzene in the Friedel-Craft's reaction with benzyl chloride or by substantially decreasing the proportion of benzene to benzyl chloride. The action of benzyl chloride on benzene in presence of Iron pyrites has been carefully studied by Smythe (T., 1922, 1276) and the various products isolated and characterised.

Uranium is, however, distinctly more basic in its tendencies than any other member of the 6th group of Periodic Table. Metallic chromium (*J. Indian Chem. Soc.*, 1928, 5, 103), molybdenum and tungsten (unpublished results) all have been tried in organic synthesis in our laboratory. The successful results with chromium have been obtained with organic chlorine compounds in which the chlorine atoms are rather loosely attached in the molecule and are very reactive. Chromium, molybdenum, tungsten all the three cannot be used either in Reformatsky or Grignard's reaction evidently on account of their much less basic character. In Ullmann's reaction, requiring increased electropositive nature on the part of the metal used for removal of the halogen atoms chromium, molybdenum and tungsten all fail, while uranium is only feebly reactive.

Details of the successful experiments are given in the experimental part, while those of the unsuccessful attempts are omitted.

Unsuccessful Attempts

Types of Reaction	Reactants	Expected Product
1. Ullmann's	Carbon tetra-chloride	Hexachloroethane
2. Friedel-Craft	Chloroform and Benzene	Tripheuyl-methane
3. ,,	Carbon tetrachloride and benzene	Triphenyl chloro-methane
4. ,,	Iodobenzene and aniline.	Diphenyl amine.
5. Grignard's	Uranium and bromo-benzene.	

EXPERIMENTAL

Friedel and Craft's Reaction with Uranium Powder

1. *Diphenyl from benzene and bromo-benzene.*—Benzene (12 g.), bromo-benzene (8·59) and uranium dust (4 g.) were refluxed for 18 hours when a very feeble reaction took place. The yield of *diphenyl* isolated on fractionation was only 0·19 g. m. p. 68°.

2. *Diphenyl from chlorobenzene and benzene.*—Reaction was carried on as above. Yield of *diphenyl* from 4 g. of uranium, 12 g. of chlorobenzene, 18 g. of benzene was only 0·2 g.

3. *Diphenyl from iodobenzene and benzene.*—Reaction was carried on as above. Yield of *diphenyl* from 12 g. of iodobenzene, 18 g. of benzene and 4 g. of uranium was only 0·25 g.

4. *Triphenylmethane from benzoyl chloride and benzene.*—Benzene (30 g.), benzoyl chloride (12 g.) and uranium dust (4 g.) were refluxed together on a water-bath for 8 hours. The dark violet product was filtered from the metal and fractionated to remove benzene and unchanged benzal chloride. The solid residue left in the flask crystallised from alcohol in needles, m.p. 92° and was identified as *triphenylmethane*, yield 0·9 g.

5. *Triphenyl chloromethane and dichlorodiphenylmethane from benzotrichloride and benzene.*—Benzotrichloride (15 g.), benzene (50 g.) and uranium dust (3 g.) were heated in an oil-bath at 115—128° C. when after half an hour's heating a fairly vigorous reaction took place. After heating for 8 hours to complete the reaction, the deep pink mixture was filtered, benzene removed by heating on the water-bath and then fractionated at 35 mm. and the fraction boiling at 198—203° and redistilled at 200—202° was identified as *dichlorodiphenylmethane* (yield 4·2 g) and the residue in the flask was crystallised from carbondisulphide and melted at 110—115° and was identified as triphenyl chloromethane, yield 1·2 g.

6. *Acetophenone from acetyl chloride and benzene.*—Benzene (18 g.) acetyl chloride (12 g.) and uranium dust (3 g.) were refluxed in a water-bath for 6 hours when a moderately vigorous reaction took place. The product was treated with ice-cold hydrochloric acid and the resulting yellow oil extracted with benzene, washed repeatedly with water, dried with anhydrous calcium chloride and fractionated; the fraction at 185—210° (redistilled at 198—200°) was collected and identified as *acetophenone*, yield 1·2 g. (6·3%).

7. *Benzophenone from benzoyl chloride and benzene.*—A mixture of benzoyl chloride (11 g.), benzene (15 g.) and uranium dust (3·5 g.) was heated on the sand-bath under reflux, till the evolution of hydrogen chloride had ceased

(8 hours). The mixture was then treated with ice-cold dilute hydrochloric acid and the benzene layer separated. It was washed with strong caustic-soda solution repeatedly and then with water, dried and fractionated at ordinary pressure. The pale yellow oil distilling at 295—310° solidified on keeping for some hours and after crystallization from alcohol melted at 46° and was identified as *benzophenone*, yield 2·3 g.

Ullmann's Reaction with Uranium Powder

1. *Diphenyl from bromobenzene.*—Bromobenzene (10 g.) and uranium (8 g.) were refluxed at 170—180° for 20 hours. The product was filtered and fractionated when after removal of bromobenzene at 155—164° a very small amount of liquid distilled above 245° and solidified in the test tube used as a receiver. After crystallization from a little alcohol it melted at 67° C. and was identified as *diphenyl*, yield ·3 g.

2. *Diphenyl from chlorobenzene.*—Chlorobenzene (10 g.) and uranium (7 g.) were refluxed at 150—160° for 20 hours and the product isolated as in the preceding case. Yield of *diphenyl* was ·2 g.

3. *Diphenyl from iodobenzene.*—Iodobenzene (10 g.) and uranium (6 g.) were refluxed at 170—190° for 20 hours and the product isolated as in the preceding cases. Yield of *diphenyl* was ·4 g.

4. *Diethyl succinate from ethyl bromo-acetate.*—A mixture of ethyl bromo-acetate (10 g.), ethyl acetate (10 g.) and uranium powder (3 g.) was refluxed at 110—120° for 15 hours and the product filtered, washed, dried and fractionated. The fraction at 200—220° (redistilled at 216—218°) was identified as *diethyl succinate*, yield 1·4 g.

5. *Adipic acid from β-iodopropionic acid.*—When β-iodopropionic acid (10 g.) was heated with uranium (7 g.) first at 100° for 2 hours and then at 160—165° for 8 hours a little iodine was liberated. The product was extracted

with hot water, filtered, and the filtrate on concentration gave *adipic acid* crystals m. p. 148°, yield 1·2 g.

6. *Diphenyl ether from phenol and bromobenzene.*— A mixture of pure anhydrous phenol (10 g.), bromobenzene (17 g.), uranium dust (3 g.) and freshly-heated anhydrous potassium carbonate (·8 g.) was refluxed at 180—200° for 12 hours. The filtered product was steam-distilled and the distillate extracted with ether. The ether extract was washed with dilute caustic soda and then with water, dried over calcium chloride and fractionated. The fraction at 240—260° (redistilled at 253—254°) was identified as *diphenyl ether*, yield 2·9 g.

7. *Succinic acid from sodium chloracetate and anhydrous sodium acetate.*—A mixture of sodium acetate (12 g.), anhydrous sodium acetate (8 g.) and uranium (3 g.) when heated at 110-120° for 1 hour gave a very vigorous reaction. The product was extracted with water and ammonia added in slight excess to precipitate uranium hydroxide, if any. The boiled and neutral filtrate was treated in the cold with neutral ferric chloride when ferric succinate was precipitated. This was filtered, washed with water thoroughly and decomposed by hydrogen sulphide. The filtrate from lead sulphide was evaporated to dryness on water-bath and extracted with ether. The ethereal extract on complete evaporation gave 1·5 g of crystalline succinic acid m.p. 185°.

Zincke's Reaction with Uranium Powder

1. *Diphenyl methane and its higher homologues from benzylchloride and benzene.*—A mixture of benzylchloride (30 g.), benzene (80 g.) dried over sodium and uranium dust (4 g.) was slowly heated in an oil-bath up to 80° when a very vigorous reaction took place and torrents of hydrogen chloride were evolved. After the first vigorous reaction had subsided, the mixture was heated at 100—110° for 4 hours.

The pink mixture was filtered from the metal and washed first with caustic soda and then with water. After dehydrating over anhydrous calcium chloride excess of benzene was removed on the water-bath and then fractionated first at ordinary pressure. The fraction between 250—280° was redistilled thrice and finally the portion distilling at 258—261° was collected and identified as *diphenyl methane*. It was a non-fluorescent colourless liquid having an orange-like smell and solidified on keeping in ice in thin radiating needles, melting at 26° (melting point of pure diphenylmethane is 26·5 in literature and 28° by J. A. Smythe (T., 1922, 121, 1276) and gave on oxidation with alkaline permanganate benzophenone m.p. 47°C. (Found : C=92·34, H=7·39 per cent. $C_{13}H_{12}$ requires C=92·85, H=7·14 per cent.)

The thick residual oil in the distilling flask was then fractionated under reduced pressure (14 m.m.) to avoid decomposition and the first fraction distilling from 210—260° and the second from 260—360° were collected and then there was left a highly coloured and exceedingly viscous liquid which set to a hard, gun-like mass on cooling but softened and fused again on gentle warming. The first fraction had a violet fluorescence and on keeping overnight became semi-solid due to the separation of considerable quantity of white crystalline mass which after removal of the oily portion by spreading on porous plate melted at 50—70°. By repeated crystallisation from alcohol, acetone, and benzene in succession it was separated into two constituents, one consisting of the more soluble fraction melting at 81—84°C and the other melting at 53—54°. That melting at 53—54° boiled at 396—400° at ordinary pressure and was identified as sym. *triphenylethane*, (Found : C=92·75, H=7·12, $C_{20}H_{18}$ requires C=93·02, H=6·98 per cent.) and that melting at 81—84° was found to be a *mixture of ortho and para dibenzyl benzenes* and as the quantity of the mixture was only 4·9 g. the complete separation of the two isomers was not possible.

A small amount of *sulphur-yellow hydrocarbon* which on recrystallisation from alcohol melted at 71° was also obtained (see *loc. cit.* T., 1922, 121, 1278.) Yield of diphenylmethane was 18·4 g. (*i.e.*, 40% of the theoretical), Sym. triphenylethane (3 g.) and dibenzyl benzene (4·9 g.) and that of yellow hydrocarbon (·1 g.); about 5 gm. of deep brown viscous residue being left in the distilling flask. The oils which accompany the crystalline hydrocarbons and were removed partly by spreading the product from original distillation fractions and partly separated out in the process of crystallisation from alcoholic solutions, resisted all attempts at crystallisation and weighed 3 gms.

Phenetolyl phenylmethane from phenetol and benzylchloride

A mixture of phenetol (20·4 g.), benzyl chloride (18·0 g.) and uranium dust (3·5 g.) was gradually heated in an oil-bath. A very vigorous reaction commenced at 70° and was completed by heating for 2 hours at 130° after the first vigorous reaction had subsided. The pink product having an intense violet fluorescence was extracted with benzene, filtered, and the filtrate washed with caustic soda and water. The alkaline washings gave nothing on acidification and extraction with ether, showing that no demethylation had taken place during the course of the reaction as in the reactions with alkyl ethers of phenolic compounds in presence of anhydrous $AlCl_3$. The well-washed benzene layer was dried over calcium chloride and fractionally distilled, the fractions above 300° being collected. (I) 305—315°, (II) 315—345°, (III) 345—370° temperature rose very quickly, (IV) a deep-red liquid was left in the distilling flask (5 gms.). The fractions (I) and (II) were combined and redistilled, the fraction distilling at 330—345° (redistilled at 338—341°) was identified as *p-ethoxy-diphenylmethane* (yield 24·2 g., *i.e.*, 80% of the theoretical)., (Found :

$C=84{\cdot}64$, $H=7{\cdot}64$, C_{15} H_{16} O requires $C=84{\cdot}92$, $H=7{\cdot}55\%$.) The residue left in the flask was an exceeding thick liquid and nothing definite and crystalline could be obtained from it.

Anisoyl phenylmethane from anisol and benzylchloride

A mixture of anisol (22 g.), benzylchloride (21 g.), and uranium dust (3 g.) was gradually heated in an oil-bath up to 70° when a very vigorous reaction took place and after it had subsided the mixture was heated at 120—130° for 3 hours. The pink reaction product having an intense violet fluorescence was extracted with hot benzene and filtered and the filtrate treated first with 5% caustic soda and then with water. The alkaline washing gave nothing after acidification and extraction with ether. The well-washed benzene layer was separated, dried over calcium chloride and fractionated at ordinary pressure, the fractions distilling above 290° collected: (I) 290—315°, (II) 315—370°, (III) 370—380°.

Fraction (1) (redistilled at 303—305°) was identified to be *anisoyl phenylmethane*, *i.e.*, *p-methoxy diphenylmethane* (yield 17·4 g., *i.e.*, 52·9%) (*cf.* Rennie, *J.C.S.*, Vol. 41, 1882, 32, 227) (Found: $C=84{\cdot}41$, $H=7{\cdot}12$, C_{14} H_{14} O requires $C=84{\cdot}84\%$, $H=7{\cdot}07\%$) and the fraction distilling at 370—380° was redistilled when most of distilled at 376—382° and was a very thick liquid with very intense greenish blue fluorescence. (Found: $C=86{\cdot}2$, $H=7{\cdot}12$, $C_{21}H_{21}O$ requires $C=87{\cdot}5$, $H=7{\cdot}10$.) It must be *dibenzylanisol* (yield 6·9 g.).

Reformatski's Reaction with Uranium Powder

A mixture of acetophenone (12 g.) dried over metallic sodium, bromacetic ester (17 g.), uranium dust (35 g.) and dry benzene (70 c.c.) dried over sodium was gently warmed

on the bath water when a feeble reaction took place. After addition of a crystal of iodine the mixture was refluxed in an oil-bath at 120—130° for 10 hours, by then the metal had become a pasty mass. After cooling, ice-cold dilute hydrochloric acid was added to decompose the complex compound, the benzene layer separated, washed with dilute caustic soda and with water, dried over calcium chloride, and then fractionally distilled under highly reduced pressure. The fraction at 112—130° (redistilled at 118—121°) was identified as β-phenyl-methyl-hydroxy-propionic ester (yield 2·4 g.).

A YELLOW COLOURING MATTER FROM THE WOOD OF ADINA CORDIFOLIA, HOOK

BY

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Adina Cordifolia (Hook) which is known as *Keli-kadam* in Bengali and *Haldu* in Hindustani, is a large deciduous tree which is found to be fairly well distributed throughout the whole of Northern India as well as Bengal, Assam and Burma. In most of the forests it grows profusely and very often it is planted as a road-side or avenue tree. The wood is very even-grained, moderately hard, lemon-yellow in colour when freshly cut but turning yellowish grey on exposure and weighs 45 pounds per cubic foot. It is suitable for furniture making and in Northern India combs are made out of this wood as well as toys and drums. The colouring matter of this wood is very easily removed by extraction with boiling water or organic solvents and as no work seems to have been done before on this subject, so the present investigation was undertaken with a view to isolation of the colouring matter in a pure state and elucidation of its constitution. The results of examination have been recorded in the experimental part of the paper.

EXPERIMENTAL

A big log of the authentic specimen of the wood was procured from Messrs. Bhupat Lal and Sons, Wood Merchants, Allahabad, and was converted into shavings. For exhaustive extraction with different solvents, the coarsely powdered shavings were taken in 20 gram lots in a Soxhlet's extractor,

and after filtration, the solvent was evaporated in each case and the residue brought to a constant weight by heating in a steam oven. The following results were obtained :

Aqueous extract.—(5·18%.) The extract was bright yellow at first, but during the course of heating in the steam oven, it gradually became brown. Microscopic examination revealed the presence of colourless crystals of calcium oxalate and the substance gave strong reactions of tannins and sugars. No essential or fixed oil could be detected.

Chloroform extract.—(·02%.) The substance was a pale yellow wax.

Petroleum ether extract.—(·03%.) This was practically identical with the chloroform extract.

Acetone extract.—(3·67%.) It was a light yellow semi-solid substance with colourless crystals of calcium oxalate disseminated throughout the entire mass. In general properties it was quite similar to the alcoholic extract.

Alcoholic extract.—(6·88%.) It is an orange-yellow semi-solid mass with a characteristic smell of the wood and a slight astringent taste. It gives a green coloration with neutral alcoholic ferric chloride, a pale yellow precipitate with alcoholic lead acetate and an intense yellow coloration with concentrated sulphuric acid. Caustic alkalies yield a yellowish brown coloration which darkens on exposure to the air. The substance reduces Fehling's solution and ammoniacal silver nitrate and gives negative tests with alkaloid reagents. Calcium oxalate is present in the substance in fairly large quantities and can be easily isolated.

Isolation of adinin.—One kilo of small shavings of the wood was repeatedly extracted with 95% alcohol in a 5 litre extraction flask until the extract was practically colourless. The combined orange-yellow extracts were distilled at the ordinary pressure until practically the whole of solvent had distilled over and the residue began to froth vigorously. It

was then allowed to stand for a week at the end of which large amount of crystalline matter separated out in the form of yellow nodules. This was filtered off washed with small quantities of alcohol and dried in the steam oven. The substance was then freed from waxy impurities by extraction with hot benzene and the purified material thus obtained was recrystallised several times from hot alcohol. The pure substance crystallises from alcohol in long, fine, glistening needles with a golden yellow colour and from glacial acetic acid in small bright yellow prisms. This substance on slow and careful crystallization is obtained from alcohol in the form of glistening needles often as long as one cm. The substance on heating darkens in colour at 195—196° becoming orange-red, shrinks at 200° and above that temperature gradually darkens and decomposes without melting. The substance is practically insoluble in cold and only slightly soluble in boiling water, and undergoes decomposition on protracted boiling. It is insoluble in chloroform, carbon tetrachloride, benzene, ether, petroleum ether and carbon disulphide. It is slightly soluble in cold and moderately soluble in hot alcohol, acetone and glacial acetic acid. It dissolves readily in solutions of alkali hydroxides but less readily in alkali carbonates and bicarbonates, forming light yellow solutions, from which the colouring matter is reprecipitated unchanged on acidification. The substance although neutral in reaction, dissolves in concentrated mineral acids like hydrochloric, hydrobromic, hydroiodic, nitric and sulphuric acids, forming bright yellow solutions, the colours of which are much more intense than that of the corresponding concentration of the colouring matter in alcoholic solution. Alcoholic solution of the substance gives no precipitate or coloration with alcoholic ferric chloride, lead acetate, calcium chloride, or silver nitrate. The substance does not reduce Fehling's solution either before or after boiling with concentrated hydrochloric acid, thereby showing

its non-glucosidal nature. The substance in alcoholic hydrochloric acid on treatment with metallic magnesium becomes reduced to a colourless substance, thereby showing that it is not a colouring matter belonging to the flavone group which by this treatment would have been reduced to a red or violet coloured flavylium salt. The alcoholic solution of the substance shows a bright green fluorescence which becomes more intense in ultra-violet light, in which also the substance dissolved in concentrated sulphuric acid shows a violet fluorescence and its solution in phenol a greenish blue fluorescence. These apparently point to the presence of an anthraquinone, a xanthone or an isoflavone nucleus in the molecule. The absence of an anthraquinone nucleus was proved by the fact that on treatment with zinc dust and ammonia it did not give any red, blue or violet coloration, but became altogether colourless. In alcoholic solution it is optically inactive. From 10 kilos of the shavings 9·1 grams of the pure substance were isolated (yield ·09%). Found in specimen dried at 120° C=60·58, 60·28, 60·50; 60·32%; H=4·63, 4·83, 4·51, 4·64%. M. W., (Cryoscopically in phenol) 299, 293, 290; $C_{16}H_{14}O_7$ requires C = 60·4; H=4·4%, M. W. 318. (Found in specimen dried in vacuum desiccator for 10 days: C = 56·55, 56·83; H = 4·83%; 4·85%; $C_{16}H_{14}O_7, H_2O$ requires C = 57·1% H=4·8%. The air-dried substance lost 16·2, 15·9, 16·3% of H_2O at 120° and 9·8, 9·6% of H_2O in the vacuum desiccator in the course of 10 days. $C_{16}H_{14}O_7, 3H_2O$ requires for loss of $2H_2O$ 9·67% and for loss of $1H_2O$ 16·6%.)

It is clear from the analytical data that the substance crystallizes from 95% alcohol with three molecules of water of crystallizes of which it loses two in the vacuum desiccator and all the three at 120°. No compound of this formula and possessing properties identical with it has been recorded in chemical literature. It is, therefore, proposed to designate this new compound "adinin", with

reference to its properties as a colouring matter and the generic name of the plant from which it has been isolated.

Demethylation of Adinin.—A carefully weighed amount of adinin dried at 120° was heated with freshly distilled hydriodic and (S. G. 1·72) in accordance with the method of Zeisel for the estimation of methoxy groups. The precipitated silver iodide was filtered off, washed with dilute nitric acid, dried at 120° and weighed. (Found: $-OCH_3 = 10{\cdot}1,\ 9{\cdot}9\%$; $C_{15}\ H_{11}O_6 - OCH_3$ requires $-OCH_3\ 9{\cdot}74\%$.)

Noradinin.—The collective product from the action of hydriodic acid, which was evidently present in the form of an oxonium salt, was poured into sodium hydrogen sulphite solution, the yellow precipitate collected. It crystallizes from boiling glacial acetic acid in the form of yellow needles which shrink at 213-214° and decompose above 232° without melting. It is practically insoluble in cold or hot water, alcohol, acetone, benzene, ether, chloroform and petroleum ether, and is fairly soluble in hot acetic acid. Alcoholic ferric chloride gives a dirty greenish grey colour with the alcoholic solution of the substance and alcoholic lead acetate throws down a pale yellow precipitate. Noradinin has not yet been obtained in sufficient quantity for combustion.

Adinin Hydrobromide.—·5 gram of adinin dried at 120° was treated with the minimum quantity of concentrated hydrobromic acid (S. G. 1·78), sufficient to dissolve it. The substance dissolved immediately forming an intense yellow solution and the clock glass containing it was kept in a vacuum desiccator containing granulated solid caustic potash for a number of days. The product when completely dry was washed with dry ether and finally dried in the vacuum desiccator. The hydrobromide was thus obtained in the form of bright orange-yellow needles which shrink

at 150-160° and decomposed above 200° without melting. (Found: Br 22·6%; $C_{16}H_{14}O_7$ H. Br requires Br = 20·05%.)

Ammonium salt of adinin.—This was obtained by dissolving ·5 gram of adinin in the smallest quantity of pure concentrated ammonia and allowing the solution to evaporate at the ordinary temperature in a desiccator over concentrated sulphuric acid for several days. The salt was obtained as orange-yellow crusts which shrink at 104-105°, completely melt at 130°, solidify and again melt at 202-203° with frothing. On exposure to air it gradually loses ammonia and becomes converted into a mixture of adinin and the ammonium salt of varying composition. The substance could not be obtained in a state of sufficient purity for analysis.

Absorption spectra of adinin.—A one per cent solution of adinin in alcohol on spectrographic examination was found to have a well-defined absorption band between wave length 4250 to 4650, with the head of the band or absorption maxima at wave length 4590 A. U. Further work on the subject is already in progress.

One of us (J. B. L.) wishes to express his indebtedness to the Kanta Prasad Research Trust of the Allahabad University for a scholarship which enabled him to undertake this investigation.

CHEMICAL EXAMINATION OF *GLYCOSMIS PENTAPHYLLA* AND THE CONSTITUTION AND SYNTHESIS OF ITS ACTIVE PRINCIPLE

BY

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Glycosmis Pentaphylla or *Limonia Pentaphylla* is a common road-side shrub found everywhere in eastern Bengal. Its Sanskrit equivalents are: बदरु and आस्वशाखोढ़: and in Bengali it is commonly known as *Ashseora* or *Matkhila*. Its stems are largely used as tooth-brush in eastern Bengal on account of their fibrous nature and slightly astringent bitter taste. Its constant use not only makes the teeth clean but also prolongs their durability. In well-known books on Indian medicinal plants like *The Indian Medicinal Plants* by Kirtikar and Basu or *The Pharmacographica Indica* by Dymock, the plant is not mentioned along with other medicinal plants of India probably on account of the fact that the plant is practically localised in the eastern part of Bengal, but some of its medicinal properties are well known even to illiterate women of that country. The bitter juice of the leaves of this plant is very widely used by them for fever, liver complaints and intestinal worms, particularly in the case of children. Occasionally the stem and the root of this plant are used on ulcers with good results. The leaves of this plant are good antidotes for eczema and other skin diseases. Its leaves made into a paste with a bit of ginger are applied over the affected part of the skin, and sometimes the paste of the leaves alone is applied over the

navel for worms and for disorders of the bowels. The different Sanskrit names of the plant as also some of its important medicinal properties as given in the famous Kaviraji book compiled by Madan Pala are as follows:

बदद्रुश्चास्वशाखोढ़: सपित्तकफनाशन: ।
वातलश्च क्रिमीन् हंति पाण्डुताज्वरकामलान् ॥

which means that the plant known as बदद्रु and also आस्वशाखोढ़: is an antidote for wind, cough, rheumatism, worms, anemia, fever and jaundice.

On account of the fact that the plant has not been described yet in any important book on Indian plants, a short description of it has been thought to be appropriate and is given below:

DESCRIPTION OF THE PLANT

Plant—shrub. Natural Order—Rutaceae. Root—tap root.

Stem—woody, rounded. Leaves—compound extipulate, imparipinnate.

Leaflets alternate, generally 5 in number, venation pinnately reticulated. Margin finely serrated, apex acute, shape elliptical, surface smooth on both sides, upper side deep green in colour, under side somewhat lighter. Inflorescence—both axillary and terminal pubescent panicle. Flower—small white with pubescent bracteoles, bisexual, regular, complete. Calyx—polysepalous, sepals five, inferion, broad at the base but pointed at the apex, hairy. Corolla—polypetallous, petals five, hypogynous, white and gland dotted, imbrecated in bud. Andrœcium—stamens free, inserted round the disk, hypogynous, filaments stout at the middle, another with an apical gland. Gynœcium—syncarpous, superior, covered with glands. Ovary—five-celled with one ovule in each cell, style short,

stigma simple. Fruit—a fleshy berry, colour reddish when ripe, fleshy mesocarp sweet to taste, only one seed is found to develop. Habitat—sparsely throughout tropical and subtropical Himalaya, Upper Assam, Travancore, Malay Archipelago, China, Philippine Island, Borneo, Australia and abundantly throughout Eastern Bengal.

On account of the great importance of the plant from the point of view of Indian medicine and particularly because no work has been done on it up to this time, the present investigation was undertaken with a view to subject the plant to a systematic chemical examination. As the result of that investigation it has now been found that the active principle "glycosmin" is present throughout the entire plant in traces only, its greatest concentration being found in the new leaves and buds to the extent of ·2%, while in mature leaves and soft stems, the percentage varies from ·08 to ·1%. Along with glycosmin the active principle, a tannin, a phlobaphene, traces of salicin, and about 2·1% of sugars (both reducing and non-reducing) have been found to be present in the leaves.

Glycosmin on further examination was found to decompose very easily into veratric acid and salicyl-aldehyde on treatment with acid permanganate, and this together with the fact that it gave all the reactions of a glucoside led the present author to surmise that probably the substance was a veratroyl derivative of salicin, which was found to be quite correct, since on boiling it with saturated baryta, it was resolved into salicin and veratric acid. This was further confirmed by the synthesis of the substance by the action of veratroyl chloride on salicin in pyridin solution. The veratroyl-salicin thus obtained was identical in all respects with glycosmin, and the mixed melting point was also the same as that of either of the substances taken separately. Glycosmin therefore is quite analogous to populin isolated from poplar buds and which is the benzoyl derivative

of salicin. Although poplar (N: O. Salicaceæ) belongs to quite a different natural order of plants than Glycosmis Pentaphylla, yet it is quite interesting to see that the buds and leaves of both contain quite analogous products. Another very interesting case of such similar products occurring in nature is afforded by the well-known aconite plant. Thus of the two types of aconite growing in Nepal, Aconitum Napellus contains acouitine which is the acetyl-benzoyl derivative of aconine, whereas Aconitum Spicatum contains bikhaconitine, which is acetyl-veratroyl derivative of aconine.

EXPERIMENTAL

Isolation of Glycosmin.—Buds and young leaves of the plant were collected from the Mymensingh district of Eastern Bengal during July, and carefully dried in the shade. Some complete plants were also collected for systematic examination. For the extraction of glycosmin, the leaves and buds were further dried at 80°C for a period of five hours. Two kilos of dried and coarsely powdered buds and young leaves were then repeatedly extracted with boiling benzene in a large extraction flask until the chlorophyll and wax were completely removed. The residue was then exhaustively extracted with alcohol and from the extract the solvent was removed by distillation. From the light brown syrup thus obtained a small amount of oily impurities were removed by extraction with petroleum ether. The syrup on subsequent standing for about a week, deposited a quantity of crystalline matter which was removed by thinning the liquid with chloroform and filtering. The substance thus obtained was crystallised from ehtyl acetate, alcohol, and 50% acetic acid in succession and finally once more from absolute alcohol. The substance crystallises from all these solvents in large colourless plates containing varying amounts of solvent of crystallisation. On quickly cooling concentrated a solution.

of the substance in various solvents, a transparent jelly is obtained. From all these the solvent of crystallisation is easily removed by first drying the substance in the air and then in the vacuum desiccator. It melts at 169°. (Found: C = 58·4, H = 6·1; $C_{22}H_{26}O_{10}$ requires C = 58·66, H = 5·77%.) The substance is only slightly soluble in water and can be crystallised from large quantities of this solvent in the same form as from organic liquids.

Isolation of salicin.—The mother liquor after the isolation of glycosmin, was freed from chloroform and dissolved in alcohol. Alcoholic lead acetate was then added until the dirty yellow precipitate no longer formed. The precipitate was filtered off and to the filtrate alcoholic lead subacetate was next added. This caused the immediate precipitation of a bright yellow crystalline precipitate which was also filtered off. From the first lead precipitate on subsequent decomposition with hydrogen sulphide an impure tannin was obtained and from the second lead precipitate a phlobaphene melting between 156—172° was derived in the same manner. The alcoholic mother liquor after the removal of the lead lakes was freed from lead by passing hydrogen sulphide, and after filtration of the lead sulphide, the filtrate was concentrated to a small volume and allowed to stand, when a further crop of glycosmin crystallised out. On adding water to the mother liquor, a white precipitate was obtained which on crystallisation from boiling water was obtained in glistening white flakes melting at 201° and was identified to be salicin. The quantity obtained was extremely small, being only about ·02% by weight of the dry leaves.

Properties of Glycosmin.—Unlike salicin which is very bitter, glycosmin has only a slightly bitter taste which becomes only apparent after keeping the substance on the tongue for some time. Unlike salicin also in concentrated sulphuric acid it dissolves at first to a colourless solution

which gradually assumes a brownish red colour. In strong nitric acid it dissolves to a bright yellow colour. The substance does not reduce Fehling's solution or Tollen's reagent, but both these reagents are rapidly reduced on hydrolysis. On warming the substance with a dilute solution of potassium permanganate acidified with sulphuric acid, a strong odour of salicyladehyde is evolved. The substance is optically active, a 5% alcoholic solution showing a lævorotation of $[\alpha]_D^{20°} = +35°$.

Decomposition of glycosmin with barium hydrate.— 2g. of glycosmin were boiled under reflux with 200 c.c. of a saturated solution of barium hydrate in water for two hours. The substance gradually went into solution and the clear liquid on cooling deposited glistening white flakes melting at 201° and which were identified to be salicin. The mother liquor on acidification with dilute hydrochloric acid yielded a heavy white precipitate which on crystallisation from aqueous alcohol was obtained in the form of glistening needles melting at 179° and was identified to be veratric acid.

Synthesis of veratroyl-salicin and its identification with glycosmin.—25 g. of veratroyl chloride were gradually added to 20 g. of salicin dissolved in 100 c.c. of pyridine at the ordinary temperature. Each addition produced a considerable rise of temperature and the mixture was cooled in cold water before the next addition. After all the veratroyl chloride had been added, the mixture was heated in the water-bath for about an hour and then poured into about 500 c.c. of cold water. The resulting white precipitate was filtered off, washed with very dilute sodium hydroxide (to remove any unchanged veratric acid and also salicin) and water and finally crystallised repeatedly from 90% alcohol. The substance was thus obtained in glistening colourless plates which on drying first in the air and finally in the vacuum desiccator melted at 169° and the melting point was not

lowered on admixture with glycosmin in varying proportions. It had all the properties of glycosmin and in fact both the substances were absolutely identical with one another. (Found: C=58·3, H=6·0; $C_{22}H_{26}O_{10}$ requires C=58·6, H=5·7%.)

The Author wishes to express his indebtedness to Prof. Hemendra Kumar Bhattacharya, M.A., Professor of Botany, Ananda Mohon College, Mymensingh, for supplying him valuable information, both botanical and medicinal, with regard to the plant.

METALLIC TITANIUM IN ORGANIC SYNTHESIS

BY

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In continuation of the work on synthetic use of rarer metals published from this laboratory (Ray and Dutt, *Jour. Ind. Chem. Soc.*, 1928, **V**, 103; Chakrabarty and Dutt, *Ibid.*, 1928, **V**, 517; Lal and Dutt, *Ibid.*, 1932, **IX**, 565; Gaind and Dutt, *Allahabad University Studies*, 1933, 291; Lal and Dutt, *Jour. Ind. Chem. Soc.*, 1935, **XI**,—) the metal titanium has now been used for the first time in organic synthesis, since it is now commercially available. The present investigation embodies the results of successful experiments with the metal while the record of unsuccessful attempts has been avoided for the sake of abbreviation.

As the result of the above investigation it has been found that metallic titanium plays a purely catalytic part in the Zincke's and Friedel and Craft's reactions that have been carried out with the metal, since the yields of the reaction products were found to be independent of the amount of metal used in the reactions. Also a very small amount of the metal was required to start the reaction in most of the reactions. Zincke's reaction gave the most satisfactory result with metallic titanium and the yields obtained in this case were consequently the highest. Ullmann's reaction with metallic titanium was far less satisfactory, and also as in the case of metallic chromium (Chakrabarty and Dutt, *loc. cit.*). Titanium also reacted only in those cases where the halogen atom was loosely attached to the organic molecule. Titanium as a neutral reducing agent, was also not much of a success. In comparison with the other metals that have been worked up

in this laboratory, it has been found that titanium is only slightly more reactive than chromium, but far less reactive than aluminum, thorium or cerium.

EXPERIMENTAL

Zincke's reactions with metallic titanium

Action of benzyl-chloride on benzene.—A mixture of dry benzene (50 g.), benzyl-chloride (24 g.) and titanium (4·5 g.) was refluxed on the water-bath for 10 hours. The reaction began after $2\frac{1}{2}$ hours and copious hydrogen chloride was evolved during the rest of the period. The filtered product was fractionated at the ordinary and also reduced pressure and three fractions, *viz.*, (*a*) at 200—270°/755mm., (*b*) at 200—250°/50mm., and (*c*) at 250—360°/10mm. Fraction (*a*), redistilled at 258—262° on keeping in a refrigerator, solidified to a mass of radiating needles melting at 25-26° and was identified to be *diphenylmethane.* (Yield 9·8 g.)

Fraction (*b*) on standing for a few days in the refrigerator, deposited a mass of crystalline matter which on recrystallisation from acetic acid melted at 57° and was identified to be *sym-triphenylethane.* (Yield 4·2 g.) The mother liquor from the above on dilution with alcohol and allowing to stand for several days deposited another crop of crystals melting at 67-68° which were identified to be *o-dibenzylbenzene.* (Yield 0·5 g.) The alcoholic mother liquor from the above on evaporation gave a viscid product from which nothing definite could be isolated.

Fraction (*c*) was found to be a complex condensation product of indefinite constitution containing chlorine.

Action of benzyl-chloride on naphthalene.—A mixture of benzyl-chloride (30 g.), naphthalene (42 g.) and titanium powder (5 g.) was heated on the water-bath for 8 hours. The product was extracted with benzene, filtered and the

filtrate fractionated at the ordinary pressure. Four fractions were collected, *viz.*, (*a*) up to 250°, (*b*) 250—320°, (*c*) 320—370° and (*d*) above 370°.

Fraction (*a*) was mainly benzyl-chloride and fraction (*b*) mainly naphthalene. Fraction (*c*) was freed from traces of naphthalene by steam distillation and again fractionated, when the greater portion of it came over at 340—355°, and a small portion at 300—320°. Both these fractions solidified on standing and the small fraction on recrystallisation from hot alcohol melted at 39-40°, and was identified to be *β-benzyl-naphthalene.* The greater fraction was crystallised from methyl alcohol in rhombic plates melting at 57-58° and was identified to be *α-benzyl-naphthalene.* Both these substances on treatment with nitric acid yielded the corresponding phenyl-naphthyl-ketone, the alpha compound melting at 72-73° and the beta compound at 79-80°. The yield of α-benzyl-naphthalene was 18 g. and that of β-benzyl-naphthalene was 10 g.

Action of benzyl-chloride on diphenyl.—A mixture of benzyl-chloride (18 g.), diphenyl (25 g.) and titanium powder (5 g.) was refluxed on the oil-bath at 120—130° for 10 hours. The product was extracted with benzene filtered and the filtrate fractionated at 10 mm. Four fractions were collected, *viz.*, (*a*) up to 100°, (*b*) 100—200°, (*c*) 200—250° and (*d*) 250—360°. Fraction (*a*) was mainly benzyl-chloride and diphenyl. Fraction (*b*) was redistilled and the distillate collected at 150—200°/10 mm. was mixed with fraction (*c*) and distilled once again. The fraction collected at 174—180°/10 mm. was a colourless oil which quickly solidified and on crystallisation from acetic acid was obtained in long glistening white needles melting at 44-45°. On oxidation with chromic acid in glacial acetic acid, the snbstance was converted into *tere-phthalic acid* and this together with the fact that on analysis it was found to have a formula $C_{19}H_{16}$ confirmed the

substance to be *p-benzyl-diphenyl*. No other substance could be isolated from the mother liquors or from the fraction (*d*), which remained as a non-crystallisable syrup. All the substances isolated in course of this experiment had very strong floral odours. (Found: C=93·4, H=6·65; $C_{19}H_{16}$ requires C=93·44, H=6·56%.) The yield of *p*-benzyl-diphenyl was 12·4 grams.

Action of benzyl-chloride on quinol-dimethyl ether.—A mixture of benzyl-chloride (15), quinol-dimethyl ether (25) and titanium powder (4) was refluxed at 130—140° for 8 hours. The product was treated with dilute caustic soda so as to dissolve any dimethylated product and then extracted with benzene. After evaporation of the solvent, the product was fractionated at the ordinary pressure and resolved into five fractions: (*a*) below 200°, (*b*) 200—280°, (*c*) 280—320°, (*d*) 320—360° and (*e*) above 360°. Fraction (*a*) was mainly moisture and benzyl-chloride, fraction (*b*) was quinol-dimethyl ether, fraction (*c*) was a yellow oil changing to deep red on keeping, fraction (*d*) was a red oil and fraction (*e*) was a dark red jelly. Fraction (*c*) on standing for about two months gave out a small amount of a pale yellow crystalline substance melting at 104-105°. This product was not noticed by previous workers and was probably *di-benzyl-quinol-dimethyl ether*, but this could not be confirmed on account of the poor yield. Fraction (*d*), redistilled at 350—360°, was found to be pure *benzyl-quinol-dimethyl ether*. (Yield 23·5 g.)

Action of benzyl-chloride on anisol.—This reaction was brought about in the same way as the one mentioned above. The product on fractionation above 290° yielded three fractions, *viz*., (*a*) at 290—315°, (*b*) at 315—345° and (*c*) at 345—380°. Fraction (*a*) redistilled at 303—305° was a very large one and was identified to be *anisoyl-phenylmethane*, i.e., *p-methoxy-diphenyl-methane*. Fraction (*b*) was a very small

one and could not be identified. Fraction (*c*), redistilled at 376—382°, was a pale yellow liquid with an intense greenish-blue fluorescence and was identified to be *dibenzyl-anisole*. (Found: C=86·1, H=7·3; $C_{21}H_{20}O$ requires C=87·5, H=7·1 %.) Yield of the first product was 63% and that of the second 12 %.

Action of benzyl-chloride on phenetol.—This reaction was also carried on in a similar way to the above. The product was fractionated and three fractions isolated, namely, (*a*) at 305—315°, (*b*) at 315—345° and (*c*) at 345—360°. Fractions (*a*) and (*b*) were mixed together and redistilled at 330—346° and once again at 338—341°, when a pale yellow oil was obtained which was identified to be *p-ethoxy-diphenylmethane.* Yield 76° %. Fraction (*c*) was a yellowish red oil which on cooling became semi-solid and was probably *dibenzyl-phenetol*, but this could not be confirmed as the product could not be purified sufficiently for analysis.

Action of benzyl-chloride on toluene.—A mixture of benzyl-chloride (25), toluene (40) and powdered titanium (4·8) was heated under reflux on an oil-bath. The reaction was very vigorous at 70° and was completed on heating at 110—120° for 10 hours. The product was fractionated as usual and four fractions were isolated, *viz.*, (*a*) at 100—200°, (*b*) at 200—260°, (*c*) at 260—285° and (*d*) at 285—360°. Fraction (*a*) was unchanged benzyl-chloride and toluene, fraction (*b*) was very small and was of indefinite composition, fraction (*c*) redistilled at 279—290° and once again at 283—287° was a colourless oil identified to be *p-benzyl-toluene* and fraction (*d*) redistilled at 260—270°/10 mm. was a colourless highly fluorescent oil which appeared to be *2:4-dibenzyl-toluene* from its analysis. (Found: C 92·4, H 7·6; $C_{21}H_{20}$ requires C 92·8, H 7·2%. *Cf.* Weber and Zincke, *J.*, *Abs.*, 1875, i, 158.) Yield of the first product was 12·8 g. and that of the second was 9·2 g.

Action of benzyl-chloride on phenol.—A mixture of benzyl chloride (15), phenol (20) and titanium (6) was gradually heated under reflux on an oil-bath. A violent reaction took place at 80° and HCl was rapidly evolved. The reaction was completed by heating at 110—120° for 8 hours. The product on fractionation at the ordinary pressure yielded two main fractions, namely, (*a*) at 310—330° and (*b*) at 360—380°. Fraction (*a*), redistilled at 315—25° and once again at 320—322°, was a colourless non-fluorescent oil with a fine flowery smell, and giving no colour reaction with aqueous or alcoholic ferric chloride. It solidified on standing in the refrigerator for nearly a month and then crystallised from alcohol in colourless glistening prisms melting at 83° and was identified to be *p-benzyl-phenol.* Yield 10·0 g. Fraction (*b*) was found to be insoluble in caustic alkalies and was apparently free from phenolic groups. It was in all probability, *p-benzyl-phenol-benzyl ether*, but this could not be ascertained for want of authoritative data. It boiled at 364—365° and was colourless oil with a strong flowery odour. Yield 1·2g. (Found: C=87·1, H=6·8; $C_{20}H_{18}O$ requires C=87·5, H=6·5%.)

Action of benzyl-chloride on acenaphthene.—This reaction which was also a very vigorous one was carried in a similar way to the above. The product was extracted with benzene and after evaporation of the solvent it was fractionated at a pressure of 10 mm. Four fractions were collected, *viz.*, (*a*) at 150—200° a colourless oil, solidifying at once, (*b*) at 200—250° a trace of an oil partially solidifying, (*c*) at 250—300° a colourless oil and (*d*) at 300—360° a red oil. Fraction (*a*) was only unchanged acenaphthene; fraction (*c*) redistilled at 260—270° partially solidified on treatment with twice its volume of alcohol and the separated crystals on recrystallisation from acetic acid melted at 49° and were identified with benzyl-acenaphthene (*Cf.* Dwonewaski and Leonhard, *J.*, *Abs.*,

1929, i, 56). The alcoholic mother liquor from the above on the slow evaporation yielded another colourless crystalline substance which on three recrystallisation from acetic acid melted at 110—111° and was identified to be 5-benzyl-acenaphthene. It gave 5 benzyl-acenaphthene-quinone on oxidation with chromic acid in glacial acetic acid, melting at 164°. Yield of the 5-benzyl-acenaphthene was 42%.

Friedel and Craft's reactions with metallic titanium

Benzophenone from benzoyl-chloride and benzene.—A mixture of dry benzene (28), benzoyl-chloride (20) and titanium powder (4·2) was refluxed on the water-bath for 30 hours. The product was fractionated at the ordinary pressure and the fraction boiling at 280—320° and redistilled at 305—315° was collected. It solidified in the receiver and on crystallisation from alcohol melted at 47° and was identified to be benzophenone. Yield 4·2 g.

Acetophenone from acetyl-chloride and benzene.—The reaction was carried on in a similar way to the above. The yield from 22 g. of benzene and 16 grams of acetyl chloride was only 1·8 grams.

Triphenyl-chloromethane from benzo-trichloride and benzene.—A mixture of benzene (30), benzo-trichloride (25) and titanium (6) was refluxed on the oil-bath at 130—140° for 10 hours. The product was extracted with carbondisulphide and after the removal of the solvent it was fractionated under reduced pressure (10 mm.). The fraction boiling at 200—250° solidified in the receiver and on recrystallisation from alcohol was obtained in the form of pale yellow needles melting at 104° and were identified to be triphenyl-chloromethane. Yield 2·8 g.

Benzoyl-benzoic acid from benzoyl-chloride and benzoic acid.—A mixture of benzoyl-chloride (15), benzoic acid (12) and titanium (5·4) was refluxed at 150—160° for 16 hours. The prodnct was steam distilled to remove the excess of

benzoic acid and then treated with a slight excess of ammonium hydroxide, which completely precipitated the titanium as hydroxide. The filtrate on concentration and subsequent acidification with hydrochloric acid precipitated the benzoyl-benzoic acid. M.P. 127°. Yield 4·2 g.

Ullmann's reaction with titanium metal.

Diphenyl ether from phenol and bromobenzene.—A mixture of phenol (15), bromobenzene (20), potassium carbonate (5) and titanium was refluxed at 180—200° for 15 hours. The reaction product was filtered and extracted with ether and the ethereal extract washed with dilute caustic soda. After the removal of the solvent, the product was fractionated, and the fraction boiling at 161° was isolated. It was a pale yellow oil with a fine flowery odour and was identified to be diphenyl ether. Yield 2·4 g.

Diphenyl-amine from bromobenzene and aniline.—This reaction was carried on in the usual manner and the yield obtained was only about 8% of the theoretical. When iodobenzene was substituted in place of bromobenzene, the yield improved to about 12%.

Succinic acid from sodium-chloracetate and sodium acetate.—This reaction was carried on in the same way as in the case of cerium (Lal and Dutt, *loc. cit.*) and the yield obtained was 24%.

Diethyl-succinate from ethyl-chloracetate and ethyl-acetate.—This reaction was carried on in the same way as above and the yield of the reaction product was about 35%.

Hexanitro-diphenyl from picryl-chloride.—A mixture of picryl-chloride (10) and titanium powder was heated at 140—150° for 15 hours. The product was extracted with benzene, the benzene extract repeatedly washed with a strong solution of caustic soda and then with water until the latter

was colourless and finally the benzene was evaporated, when a brownish yellow crystalline mass was obtained. On recrystallisation from alcohol it was obtained in bright yellow needles melting at 238° and was identified to be hexanitro-diphenyl. Yield was only ·91 g.

Reformatsky's reaction with titanium powder

A mixture of dry acetophenone (10), bromacetic ester (17), titanium powder (10) and dry benzene (70) was refluxed on the water-bath for four hours. After treatment with ice-cold dilute hydrochloric acid the benzene layer was separated out and after removal of the solvent, the product was fractionated and the fraction passing over at 120—125°/4 mm. was identified to be β-phenylmethylhydroxy-propionicester. Yield 2·1 g.

Neutral reduction with titanium powder

Neutral reductions with titanium powder were not very satisfactory, since in each case the yield was unsatisfactory. The reductions were carried on according to the method of Lal and Dutt.

Picramic acid from picric acid.— The yield was only ·5 g. from 2 g. of picric acid.

Benzohydrol from benzophenone.— The yield was ·66 g. from 2g. of benzo-phenone.

O-*amino-phenol from o-nitro-phenol.*—Yield was ·2 g. from 2 g.

Aniline from nitrobenzene.— The yield was 3 grams. from 10 g.

COLOUR AND CONSTITUTION OF DYESTUFFS DERIVED FROM FLUORENONE

BY

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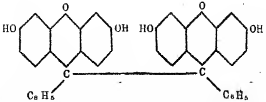
The phthalein type of dyestuffs have been known for a very long time, the first phthalein—fluorescein—having been prepared by Bayer in 1872. Since then almost all anhydrides of dibasic acid, saturated or unsaturated and belonging to the aliphatic, aromatic or heterocyclic series have been condensed with aromatic amino and hydroxy compounds with formation of dyestuffs. The pyronine type of dyestuffs obtained by condensations of aldehydes with aromatic amino and hydroxy compounds were first prepared by Otto Fischer in 1875, and although the number of such compound has been extended by later workers, yet they seem to have received far less attention at the hands of chemists than the phthaleins.

Very little attention has however been paid to the ketones as a source of dyestuffs. The first successful attempt in this connection seems to be that of Hans Von Liebig,[1] who prepared by heating together a mixture of benzil and resorcinol with or without the addition of fused zinc chloride, the compound:

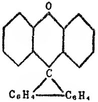


This has been described as similar to fluorescein in properties. Later on Scharwin and Kusnez[2] prepared from

anthraquinone and resorcinol a condensation product very similar to the above. Very recently, Sen, Chattopadhaya and Sen-Gupta[3] have prepared a number of pyronine dyestuffs from several aliphatic and aromatic ketones, such as acetone diethyketone, acetophenone, benzophenone, etc. The condensations were effected by heating with zinc chloride. The properties of most of the substances were closely analogous to the corresponding phthaleins.

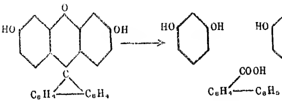
The neglect which this class of compounds has received at the hands of colour chemists is apparently due to the fact their constitution is not amenable to a representation in the quinonoid form, which has invariably been thought to be the cause of colour of the pyronines and phthaleins.

The present investigation was undertaken to prepare dyestuffs from the interesting cyclic ketone—fluorenone. and to find out whether they correspond in properties to the analogous phthaleins or pyronines. The condensation products which are easily obtained, and which have the following skeleton structure:



have been named diphenylene-xanthenes for obvious reasons. They have properties very similar to the pyronine dyestuffs, as will be apparent from the experimental parts of the paper. The constitution of the compounds is apparent from the fact that on fusion with caustic soda, all of them undergo fission with formation of the phenol from which they were formed and diphenyl-o-carboxylic acid. Thus 2:7-dihydroxy-diphenylene-xanthene (from resorcinol and fluorenone) on

fusion with caustic soda yields resorcinol and diphenyl-o-carboxylic acid in the following manner:



The above constitution for the resorcinol compound is further corroborated by the fact that it forms a disodium salt and also a dibenzoyl derivative. All other hydroxy compounds also behave similarly.

A comparison of the dyestuffs derived from fluorenone with the corresponding phthaleins show that in general the colour and intensity of fluorescence of the former is much less than the latter. But nevertheless the relation between the positions of the absorption maxima is about the same in both the series of dyestuffs. From this also it appears quite conclusive that apart from the difference in the intensity of colour and fluorescence caused by the use of different starting materials, there is no fundamental difference in the constitution of the two types of colouring matters.

Another very interesting fact that has been found out in connection with the present investigation is the effect of different groups or radicals on the pyronine nucleus. Thus the condensation products of acetone, methylethylketone, diethylketone, benzaldehyde, acetophenone, benzophenone and fluorenone with resorcinol although have quite analogous constitution yet their absorption maxima is very different from one another as will be apparent from the following table :

Dyestuff from			Absorption maxima
Acetone	...	...	4290
Methylethylketone	...	...	4680
Diethylketone	...	...	4740

Dyestuff from			Absorption maxima
Benzaldehyde	...	...	4940
Acetophenone	...	...	5030
Benzophenone	...	...	5185
Fluorenone	...	...	4195

From the above figures, the gradual increase in the colour with the increase of the molecular weight of the radicals attached to the main xanthene nucleus will be apparent. The increase is not of course gradual as could have been expected by calculation. Actually in the case of the acetone compound the substitution of one methyl for ethyl produces a jump in the absorption, but changing the other methyl to ethyl also brings about a comparatively small effect. Similar is in the case of substitution of a phenyl radical. But it is exceedingly interesting that two coupled benzene nuclei in the case of the fluorenone compound should produce such a remarkable lowering of the intensity of colour as compared with the benzophenone derivative.

The dyestuffs derived from fluorenone as also similar compounds derived from other ketones are undoubtedly non-quinonoid in character, since it is not possible to attribute to them any quinonoid configuration even with a considerable stretch of imagination. But nevertheless they have properties perfectly analogous to the phthaleins which have been definitely proved to have quinonoid constitution by a number of authors.

The following aromatic amino and hydroxy compounds have been condensed with fluorenone and the following dyestuff obtained: resorcinol, catechol, orcinol, pyrogallol, phloroglucinol, m-dimethylamidophenol and m-diethylamidophenol. The hydroxy compounds have in most cases been dibrominated and their disodium salt and dibenzoyl derivative been obtained. The condensations have invariably been effected by hydrogen chloride at 180—200°.

EXPERIMENTAL

Several condensing agents were tried for bringing about the reaction between fluorenone and aromatic hydroxy and amino compounds, *e.g.*, sulphuric acid, anhydrous zinc chloride, hydrogen chloride, acetic anhydride, etc. In all cases zinc chloride and hydrogen chloride were found to be most effective. But when zinc chloride was used, a small residue of zinc always remained in the condensation product in spite of all attempts to eliminate the same. Consequently hydrogen chloride was used in all the cases. The general method of condensation consisted in taking one molecule of fluorenone and two molecules of the phenol or amino phenol in a test tube immersed in an oil-bath heated at 180—200°, and when the mixture had melted, in passing dry hydrogen chloride through the molten mass until complete condensation was effected. The usual period of heating varied from three to five hours. For the sake of abbreviation only a brief description of the properties of the condensation products are given.

2 : 7-dihydroxy-diphenylene-xanthene.—Prepared from resorcinol and fluorenone. It crystallised from benzene in yellow prisms melting at 232°. It is fairly soluble in most of the organic solvents, but insoluble in water. The colour of the solution is bright yellow, and it shows a moss-green fluorescence. Solutions in caustic alkalies have only slightly deeper colour and fluorescence. (Found: C=82·17, H=4·30; $C_{25}H_{16}O_3$ requires C=82·4, H=4·39%.)

The *disodium salt* was prepared by treating the dyestuff dissolved in absolute alcohol with the theoretical quantity of alcoholic caustic soda, and evaporating the solution. The crystalline substance was recrystallised from absolute alcohol in fine orange leaflets which did not melt on heating. (Found: Na=11·35; $C_{23}H_{1405}Na_2$ requires Na=11·27%.)

The *dibenzoyl derivative* was prepared by the usual method and crystallised from pyridine in light yellow microscopic needles, melting at 212°. The substance is insoluble in alkalies. (Found: C=81·76, H=4·17; $C^{39}H_{24}O_5$ requires C=81·81, H=4·19%.)

The *dibromo derivative* was prepared from the resorcinol compound by adding an excess of bromine in alcoholic solution to the substance dissolved in alcohol. On allowing the mixture to stand at the ordinary temperature, the dibromo derivative crystallised out in reddish violet needles which were recrystallised from alcohol. M. P. above 300°. The substance dissolved in most of the organic solvents and also in alkalies with a reddish pink colour and a pale green fluorescence. (Found: Br 31·3; $C_{25}H_{14}O_3Br_2$ requires Br 30·41%.)

1 : 8-dihydroxy-diphenylene-xanthene.—This was prepared from fluorenone and catechol. The substance crystallises from a large volume of water in long glistening golden yellow needles containing a large volume of water of crystallisation. On drying in the steam oven or in the desiccator the water was lost and the substance was reduced to an orange-red powder melting at 169°. The substance is soluble in most of the organic solvents and also in water forming a bright yellow solution without any fluorescence. In caustic alkalies however an intense green colour is developed which is perfectly stable in the air. (Found: C=82·05, H=4·3; $C_{25}H_{16}O_3$ requires C=82·4, H=4·39%.)

The *disodium salt* was prepared as before and crystallised from absolute alcohol in intense green crusts. (Found: Na=11·32, $C_{25}H_{14}O_3Na_2$ requires Na=11·27%.)

The *dibenzoyl derivative* was prepared as usual and crystallised from pyridine. Light yellow powder, M. P. 141°. (Found: C= 81·89, H=4·17; $C_{39}H_{24}O_5$ requires C=81·81, H=4·19%.)

The *dibromo derivative* was obtained as before and crystallised from alcohol in yellow prisms which did not melt even at 300°. It gives bright orange-red solutions in alkalies. (Found: $Br=31\cdot1$; $C_{25}H_{14}O_3Br_2$ requires $Br=30\cdot4\%$.)

*2 : 7-dihydroxy-*4 : 5 *dimethyl-diphenylene-xanthene.*—This was prepared from fluorenone and orcinol. It crystallised from alcohol in light brown microscopic needles melting above 300°. In properties it is very similar to the rosorcinol compound. (Found: $C=82\cdot8$, $H=5\cdot16$; $C_{27}H_{20}O_3$ requires $C=82\cdot65$, $H=5\cdot1\%$.)

1 : 2 : 7 : 8-tetrahydroxy-diphenylene-xanthene was obtained from fluorenone and pyrogallol. It crystallises from large volumes of water in shining yellow needles melting at 181°. The substance dissolves in alkalies with a dark reddish brown colour and from the solution a chocolate-brown precipitate is obtained on acidification. (Found: $C=76\cdot10$, $H=4\cdot09$; $C_{25}H_{16}O_5$ requires $C=75\cdot75$, $H=4\cdot04\%$.)

The *disodium salt* was prepared as usual and was obtained from alcohol as a brown powder extremely soluble in water. (Found: $Na=10\cdot53$; $C_{25}H_{14}O_5Na_2$ requires $Na=10\cdot45\%$).

2 : 4 : 5 : 7-tetrahydroxy-diphenylene-xanthene was prepared from fluorenone and phloroglucinol. It could not be crystallised, but was obtained from alcohol a light brown powder melting above 300°. It dissolves in organic solvents to a bright yellow solution possessing a feeble green fluorescence. In caustic alkalies the colour is orange-red and the fluorescence is also more intense. (Found: $C=75\cdot72$, $H=4\cdot02$; $C_{25}H_{16}O_5$ requires $C=75\cdot75$, $H=4\cdot04\%$.)

2:7-tetramethyldiamido-diphenylene-xanthene.—This was prepared from fluorenone and m-dimethylamidophenol. The substance crystallised from alcohol in violet-red prisms melting at 111°. The substance is soluble in all the organic solvents and also in dilute acids with a bright pinkish red

solution with a dull yellow-brown fluorescence. (Found: $N=6{\cdot}6$; $C_{29}H_{26}ON_2$ requires $N=6{\cdot}69\%$.)

2 : 7-tetraethyldiamido-diphenylene-xanthene.—This was prepared from m-diethylamidophenol and fluorenone. It crystallised from alcohol in dark violet crusts melting at 127° and had properties similar to the above compound. (Found: $N=5{\cdot}82$; $C_{33}H_{34}ON_2$ requires $N=5{\cdot}90\%$.)

ABSORPTION MAXIMA OF DYESTUFFS DERIVED FROM FLUORENONE

Dyestuff derived from fluorenone and	Absorption maxima
Resorcinol	4195
Ditto, dibromo derv.	4260
Catechol	4619
Ditto, dibromo derv.	4740
Pyrogallol	4535
Ditto, dibromo derv.	4696
Phloroglucinol	4219
m-Dimethylamidophenol	5074
m-Diethylamidophenol	5086

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SECTION II

ZOOLOGY

THE VACUOME HYPOTHESIS

BY

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INTRODUCTION

In a recent paper (1934) Professor Gatenby writes: "It may be said at once that the majority of workers on tissue culture believe the first hypothesis of Parat and Painlevé namely that the Golgi apparatus is merely the artificial coalescence of vacuoles stainable in neutral red. That this is so became clear to us at the International Experimental Cytological Congress at Cambridge, 1933." That the controversy round the "Vacuome" theory is still far from being closed, needs little emphasis; it becomes abundantly clear on a perusal of the recent literature written round the deposition of the neutral red in the living cell, *i.e.*, "Vacuome".

The present work is the result of an attempt to investigate the behaviour of the cytoplasmic components in supravitally stained eggs of a number of animals—Columba intermedia, Gallus bankiva, Rana tigrina, and Saccobranchus fossilis. The stains used were the freshly prepared solutions of neutral red, gentian violet, aniline blue, and trypan-blue. Neutral red was prepared according to the senior author's direction given in Bolles Lee's Vade Mecum, and the other stains were prepared almost of the same concentration. The dyes were further diluted before use by adding 5 drops of the same to 50 c.c. of Ringer's Salt Solution. Pieces of ovary were also studied in unstained condition in Ringer's Salt Solution.

OBSERVATION

Pigeon

The young unstained oocytes of Columba intermedia invariably show a dense juxtanuclear cytoplasmic area—the so-called Yolk-Nucleus of Balbiani—which stands out in sharp contrast to the rest of the cytoplasm due to its striking opacity. A few refringent granules can be perceived in it, which are found to have increased considerably in older eggs, and are ejected if the oocyte is ruptured by a slight pressure of the coverslip, and begin to execute vibratory movements. These refringent granules are identified as the Golgi bodies.

When small pieces of the ovarian tissue are immersed in a solution of neutral red the first indication of the neutral-red granules appears after about twenty minutes. Fig. (1) represents a young oocyte which has been kept immersed in neutral red for such a length of time. The "Yolk-Nucleus of Balbiani," as mentioned above, comes into view as a sharply staining juxta-nuclear area of denser cytoplasmic texture, with two kinds of granules showing prominently in its substance, *i.e.*, the unstained refringent granules and the neutral-red granules. The rest of the cytoplasm at this stage is completely unstained, and is practically devoid of these inclusions.

The neutral-red granules are small roundish structures, and at this stage they are nearly of the same size as the refringent granules—the Golgi bodies—with which, however, they can hardly be confused, as both are observed occurring simultaneously. After about fifteen minutes the neutral-red bodies increase greatly in size through the increased absorption of the dye and not through the coalescence of the previously existing ones, as is clear from a comparison of Figures 1 and 2. Moreover, there appears to be no evidence that with the lapse of time, new-neutral red bodies are secondarily produced

by the prolonged effect of the dyestuff. They remain confined to the juxta nuclear area even at this stage and do not appear at other places in the cytoplasm (Figs. 2 and 3). The Golgi bodies likewise occur in this position, uniformly distributed between the swollen "Vacuome", and never take up the red stain (Figs. 2 and 3).

That the refringent granules are nothing other than the Golgi bodies is confirmed by the study of the effect of osmic acid over a supra-vitally stained cell (Fig. 4). The "Vacuome" remain as such but the refringent granules take up a greyish to black hue, which becomes more prominent with time, till the prolonged exposure to osmic renders the cell completely opaque and unfit for study.

In the advanced oocytes (Fig. 5) the vacuome get distributed uniformly throughout the cell, and show no particular arrangement although patches appear in an earlier stage (Fig. 4). On prolonged treatment (1 hour or more) some of them swell up to form big spherules, but show no other alteration. It may be mentioned here that neither albuminous yolk bodies, nor fatty yolk bodies show any tendency to take in the neutral red colour during the early stages of the experiment, though after the lapse of $1\frac{1}{2}$ hours, some of the fat bodies may be tinged red.

Gallus bankiva

In Gallus the early stages of neutral-red staining provide the same results as in the Columba, with this difference that the former is not suitable for a study of simultaneous occurrence of the two cytoplasmic components. In older eggs, however, the vacuome appear in patches (Fig. 6) which on closer inspection appear to consist of discrete swollen elements, with a tendency to run together. As in the pigeon, the yolk bodies remain unstained.

Rana tigrina

In Rana tigrina the vacuome first begin to come into view as a few distantly isolated granules, but within 45 minutes the entire cytoplasm is filled with a number of distinctly separated patches which consist of red granules of various sizes (Fig. 7). The patches do not appreciably increase in size with the increased duration of the staining and no new ones are apparently added to the previous ones. As in other cases, the dye does not stain any inclusions that are already visible in the cytoplasm without the application of any reagent. The patches maintained this condition nearly as long as the cell kept alive.

Saccobranchus fossilis

The vacuome begin to appear after thirty minutes, and within forty-five minutes the entire cytoplasm is completely studded with numerous small regular roundish bodies stained bright pink which at times align to form short filamentous structures but never associate to form regular patches (Fig. 8). They are uniformly dispersed through the entire expanse of the uncoloured cytoplasmic background and never show any tendency to arrange themselves in any particular way. Even if this tissue is kept immersed in the dye for two hours, the vacuolar granules do not swell up to any marked extent and do not run together to form artificial patterns of any description, but retain their original size and shape. The vacuome begin to be effected seriously only with the approach of the death of the cell.

EXPERIMENTS WITH OTHER DYES

Gentian Violet.—Gentian violet failed to stain the cytoplasmic inclusions of the eggs of any of these animals but,

on the other hand, produced a uniform diffuse colouration of the entire cytoplasm. It coloured very prominently the 'Yolk nucleus' in the eggs of Saccobranchus fossilis, but the staining was dense and uniform and was, therefore, unfit for the investigation of structural characters.

Trypan blue.—Trypan blue as a supra-vital stain yielded as poor a result as gentian violet. It stained very successfully the oocyte nucleus and neucleoli, but failed disappointingly to colour any cytoplasmic cell components, and after about forty-five minutes very injurious effects on the cytoplasm were perceptible. Big colourless vacuoles began to appear till the entire cytoplasm was converted into an apparently frothy vacuolated mass.

Aniline blue.—The stain produced a uniform colouration of the cytoplasm and brought forth no cell inclusions to view.

DISCUSSION

A consideration of the 'Lepidosome' theory is deliberately left out of account in the present work for the following two reasons:—Firstly, there is little experimental evidence of a mitochondrial transformation into a structure behaving like the typical Golgi body; in other words, the "Chondriome Actif" is an unjustifiable connotation, and in the absence of absolute and incontrovertible proofs of the mitochondrial origin of the structure, the rule of priority alone should have prevented the coinage of a new term for a structure already known. Secondly, even an assumption of the correctness of the "Lepidosome" hypothesis does not seriously affect the main issue before cytologists, which is,—Are the neutral red vacuoles the homologues of the classical Golgi bodies as revealed in fixed tissues?

It is of interest to note that the results that led Parat to formulate this Hypothesis in the first instance arose out of an investigation of the secretory cycle of gland cells—the salivary

gland cells of the chironomous larva. Subsequent workers who covered the same ground brought out the interesting fact that Parat and his collaborators had simply missed the typical Golgi structure which did exist in the salivary gland cells of chironomous larva in addition to Parat's Vacuome [Krjukowa (1929), Beams and Goldsmith (1931), Gatenby (1932)]. Beams and King write—"This makes it seem very likely that Parat and Painlevé never saw the Golgi material at the time of their original publication. The suggestion was made by Krjukowa and by Beams and Goldsmith that what Parat and Painlevé were describing as Golgi apparatus simply represents secretory material. The massive network which they figure following staining with neutral red probably represents the fluid secretion in the net-like intracellular canaliculi."

Gatenby (1932) showed that neutral red exerted an injurious effect upon the architecture of the cell and created artificial cavernous spaces which got filled with neutral red and appeared as the "Vacnome," but which were certainly not pre-existent.

Chlopin (1927) carried out an extensive investigation on the effect of the vital stains on the living cells of a wide range of animals, and, as a result, expressed the view that while neutral-red stains pre-formed granules, it also originates secondarily formed bodies which he calls "Krinom" (*vide* Ludford, 1930).

Ludford further says, "Following the injection of neutral red into living mice, dye droplets appear in the Acinar cells. I have not seen them appear when the pancreas is teased out in saline containing neutral red and examined under the microscope at room temperature. By this method secretion granules are ultimately stained. Such experiences suggest that the formation of the dye droplets is brought about by the vital activity of the cells and is not due to a passive staining of pre-formed droplets." Further he showed that following certain techniques, the neutral red 'Vacuome'

could be fixed. Thus he obtained pictures of cells containing the neutral-red vacuome and the Golgi bodies simultaneously. As a result of neutral-red staining Golgi apparatus undergoes an alteration, and is broken up.

Beams (1931) was also able to fix the vacuome and the Golgi bodies in the same cell, and thus offered a demonstration of the independence of the two structures.

Bhattacharya and Das (1929) were likewise able to demonstrate the simultaneous occurrence of the Golgi bodies, vacuome and mitochondria. Similar results were obtained by many others, e.g., Tretjakoff, Grabowski and Rumjantzew [*vide* Young (1932)]. Voinova, Hirschler, Monne, and Gatenby [*vide* Gatenby (1929)] worked out the separate roll of the two structures in spermatogenesis.

It seems apparent that the Golgi apparatus is a structure entirely independent of Parat's neutral-red vacuome, while the latter may cover a variety of structures and formations from Prezymogen granules of Benseley [Gatenby (1931)], to the Krinom of Chlopin.

The results of the neutral-red staining of Protozoa [Joyet-Lavergne, Hall, Volkonsky and others—*vide* (Hall and collaborators 1931)] should be entertained with considerable caution as the homology of the various inclusions in Protozoa is not properly understood, and to offer a solution of the problem on the basis of such a work is apparently risky. They seem, however, to be in favour of the 'Vacuome' Hypothesis, inasmuch as it has been shown by some that the neutral-red vacuome go black by osmication and are apparently Golgi bodies.

It may be mentioned here that the findings of Covell and Scott on spinal ganglion cells in injected specimens of rat, appear to offer a support to Parat's hypothesis, but Beams (1931), who repeated the experiments on the same material, showed that the Golgi bodies and the neutral-red granules can be demonstrated to coexist in the same cell.

The results of the present investigation leave no doubt as to the separate identity of the Golgi bodies, which are entirely independent of the vacuome and can be seen in the living condition of the egg without the assistance of any reagent. They don't stain with neutral red and the vacuome and the Golgi bodies can be demonstrated at the same time in the same cell.

EXPLANATION OF FIGURES

Fig. 1. A young oocyte of pigeon after 20 minutes of supra-vital staining.

Fig. 2 The same after 45 minutes.

Fig. 3. A young oocyte of pigeon after 30 minutes of supra-vital staining.

Fig. 4. A young oocyte of pigeon supravitally stained and subsequently treated with Osmic Acid.

Fig. 5. A more advanced oocyte of pigeon supravitally stained (after 45 minutes).

Fig. 6. Part of a supravitally stained oocyte of Gallus bankiva after 45 minutes.

Fig. 7. Part of a supravitally stained oocyte of Rana tigrina.

Fig. 8. Part of a supravitally stained oocyte of Saccobranchus fossilis.

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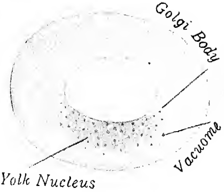

Fig. 1

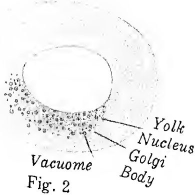

Fig. 2

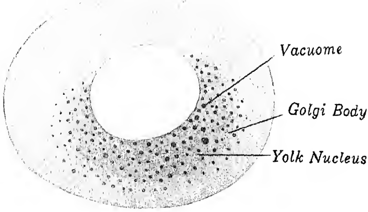

Fig. 3

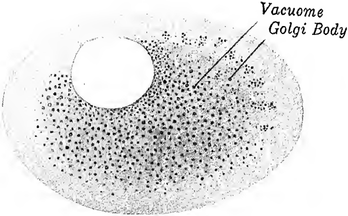

Fig. 4

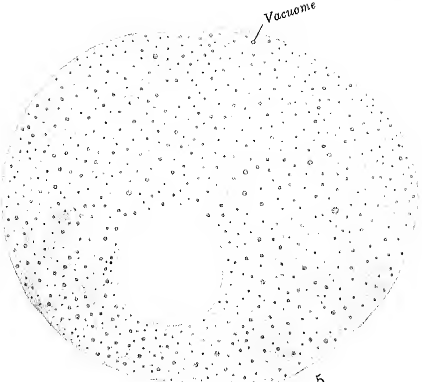

Fig. 5

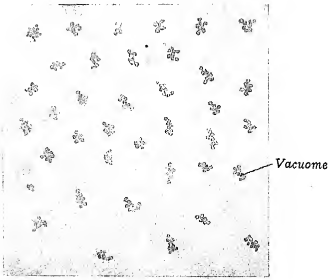

Fig. 6

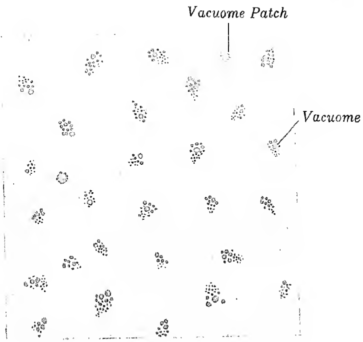

Fig. 7

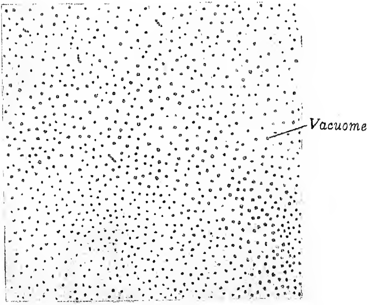

Fig. 8

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SECTION III

BOTANY

AN ESTIMATION OF THE COMPARATIVE VALUE OF VARIOUS FRESH FRUIT MEDIA IN REGARD TO FUNGAL GROWTH

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I. INTRODUCTION

The present paper is an investigation of the properties of media prepared from certain Indian fruits in relation to the cultural study of four fungi belonging to the Deuteromycetes. In this work, Brown's starch synthetic medium was also used and taken as a standard for purposes of comparison. As far as possible, all the conditions for the experiments were kept well-defined and uniform to give a fair comparison of the results. The pH value of the different fruit juices was determined by the colorimetric method.

Ten fungi, Nos. 1—10, were collected from different sources. They all belonged to the group Deuteromycetes. Out of these Nos. 6, 7, 9 and 10 were selected because of their relative importance.

No. 6 ...	...	... *Fusarium sp.*
No. 7 ...	...	... *Macrosporium sp.*
No. 9 ...	...	... *Acrothecium sp.*
No. 10 ...	...	... *Spicaria sp.*

The media employed and the abbreviations used to denote them are given below :—

1.	Brown's starch-synthetic medium	... "Brown's-starch."
2.	Apple decoction-Agar, No. I	... "Apple I."
3.	Apple decoction-Agar, No. II	... "Apple II."
4.	Grape decoction-Agar, No. I	... "Grape I."
5.	Grape decoction-Agar, No. II	... "Grape II."

6. Ripe Guava decoction-Agar, No. I "Guava I."
7. Green Guava decoction-Agar, No. II "Guava II."
8. Banana decoction-Agar ... "Banana."
9. Orange juice-Agar ... ... "Orange."
10. Papaya decoction-Agar ... "Papaya."

Single-spore cultures were obtained in every case. The colours were identified by comparison with the shades in Ridgeway's "Colour Standards and their nomenclature." The difficulty in counting the septa of granular or vacuolate spores was overcome by using ruthenium red. The septation mode was calculated by counting the septa of about 100 spores.

II. DIFFERENT MEDIA AND THEIR EFFECT ON FUNGOID GROWTH

1. Brown's synthetic medium with starch:—

Preparation.—

Asparagin	2 grams.
Magnesium sulphate	·75 grams.
Glucose	2 grams.
Potassium phosphate	1·25 grams.
Starch	10 grams.
Agar-agar	15 grams.
Distilled water	1000 c.c.

The pH value of this medium, as determined by the colorimetric method, was 7.

Brown (9) suggests that the measurement of the colonies should be started 48 hours after inoculation in order to allow for the time taken by the spore to germinate and the rate of growth to become uniform. Hence the measurements and all other records were started on the second day after inoculation. The term "radial advance" of a colony is used here in the same sense as used by Horne and Mitter (6). It is the length of the radius of the colony, which is usually more or less circular.

Range of temperature during experiment.—22°C—24°C.

Graph 1 shows the course of the daily radial advance of the four fungi, Nos. 6, 7, 9 and 10 on Brown's starch medium. On the basis of their average rate of growth, the fungi can be arranged in this descending order: Nos. 6, 10, 9, and 7.

Macroscopic and microscopic characters were observed from cultures of 8 to 10 days old, and the observations are given below :—

Characters	No. 6	No. 7	No. 9	No. 10
Colour of the mycelium.	Pale flesh color.	Margin, Pale Olive Buff. Centre Dark Olive.	Vinaceous Fawn.	Pale Pinkish Buff.
Colour of substratum.	Warm buff (after 15 days).	Absent.	Absent.	Absent.
Development of aerial mycelium.	Absent at first. After 4 days, good.	Not good.	Poor.	Very good.
Nature of growth.	Non-staling ...	Non-staling.	Non-staling.	Non-staling.
Zonation ...	Absent.	4 faint zones.	Absent.	Absent.
Sporulation ...	Good.	Good.	Poor.	Good.
Range of size of spores in μ.	25·2 × 4·2 to 44·8 × 4·2.	2·8 × 2·8 to 44·8 × 9·8.	Mostly 28 × 11·2.	Less than 2·8 to 16·8 × 4·2.
Septation mode.	5-mode.	Spores Muriformis.	3-mode.	Aseptate.
Other pronounced features.	Absent.	Absent.	Masses of twisted hyphæ.	Absent.
Saltations ...	Appeared after 4 days.	Absent.	Appeared after 5 days.	Absent.

Shape and character of spores :—

No. 6.—The spores had sharp pointed ends, curved to form a crescent shape ; 2 to 5-septate ; mostly hyaline and a few vacuolate. (See figure 1.)

No. 7.—The spores were variously shaped, round, ovoidal and club-shaped, mostly muriform. Some were aseptate, others 1- to 7-septate ; but in most of the spores, the second cell or other cells were longitudinally or obliquely divided by a septum, while the rest of the portion had transverse septa. They were dark, slightly granular, and either rough or smooth-walled. (See figure 2.)

No. 9.—The spores were uniformly of a regular shape as shown in figure 3. They were 3-septate; non-vacuolate ; granular, dark in colour. The two end cells less dark than the two central ones. One of the two central cells exhibited a prominent bulging. (See figure 3.)

No. 10.—The spores had various shapes from round, ovoidal, ellipsoidal to cylindrical ; sometimes pointed at one end only. Usually boat-shaped ; aseptate and hyaline. (See figure 4.)

2. Apple Decoction-Agar, No. I

The apples used were Sturmer pippins, from Kumaon orchards, and were obtained in the month of October. Fractional steam-sterilization is recommended. The pH value of the decoction was 5·5. The medium was prepared according to the following formula:—

Decoction from	...	50 grams of apple pulp.
Agar-agar ...	...	20 grams.
Distilled water	...	1000 c. c.

Range of temperature during the experiment.—29·5°C—32·2°C.

Graph 2 shows the course of the daily radial advance of the four fungi on Apple I. The rates of growth of Nos. 7, 9 and 10 fell with the age of the cultures, but the rate of growth of No. 6 gradually rose till the end of the 7th day. Taking into consideration the average radial advance of the fungi, the following series can be arranged in a descending order: Nos. 9, 6, 10 and 7.

Macroscopic and microscopic characters

Characters	No. 6	No. 7	No. 9	No. 10
Colour of the mycelium.	Pale Pinkish Buff.	Light brownish Olive.	Mouse gray.	Pale Pinkish buff.
Colour of the substratum.	Absent.	Absent ...	Absent ...	Absent.
Development of aerial mycelium.	Almost absent.	Poor ...	Poor ...	Poor.
Nature of the growth.	Non-staling.	Non-staling.	Non-staling	Non-staling.
Zonation ...	Faint, visible against light.	5 zones ...	5 zones ...	Absent.
Sporulation ...	Fair ...	Good ...	Not good.	Very good.
Range of size of spores in μ.	13·5 × 2·7 to 54 × 5·4	5·4 × 5·4 to 56·7 × 14·85	13·5 × 8·1 to 26·6 × 13·5	From less than 2·8 to 16·2 × 4·05.
Septation mode.	4-mode ...	Spores muriformis.	3-mode ...	Aseptate.
Other pronounced features.	...	...	Chlamydospores.	...

Shape and character of spores:—

No. 6.—The spores were sharply pointed at both ends, curved to form a crescent shape. Rarely the curvature is more prominent at one end,

Spores hyaline; very few show feeble granularity and frequent irregularity in form-Spores 3-to 5-septate. (See figure 6.)

No. 7.—The spores were similar in shape and character to those on Brown's-starch, except that the spore-wall was thicker.

No. 9.—Spores were exactly like those on Brown's-starch.

No. 10.—Spores similar to those on Brown's-starch, except that here they exhibited prominent granularity, and there were no vacuoles.

3. Apple Decoction-Agar, No. II

The apples used in this experiment were of the ordinary hill type but the exact locality could not be ascertained. They were obtained in the month of December and were reddish-pink, quite ripe and sound.

Average size, 6×6 cms. (vertical and horizontal diameters).

Preparation.—

The decoction was prepared in the same way as in Apple I, pH, 4·7. Here the concentration of the medium was greater. The formula is:—

Decoction of......................200 grams of apple.

Agar-agar..........................18 grams.

Distilled water...................1000 c.c.

Range of temperature during the experiment.—21°C—23°C.

Graph 3 shows the course of the daily radial advance of the four fungi on Apple II. It shows a double rise and a double fall in all except No. 6, where there was a third rise. The best rate of growth was obtained for No. 10, then followed Nos. 7, 6 and 9.

Macroscopic and microscopic characters

Characters.	No. 6.	No. 7.	No. 9.	No. 10.
Colour of the mycelium.	Light Pinkish Cinnamon.	Buffy olive	Tawny	Seashell Pink.
Colour of the substratum.	Absent.	Absent.	Tawny.	Absent.
Development of the aerial myoelium.	Absent.	Poor.	Poor.	Almost Absent.
Nature of the growth.	Non-staling.	Non-staling.	Staling	Non-staling.
Zonation.	4 faint zones.	5 zones. Dark and light alternating.	3 zones. Outer-1 om Middle-·3 om. Inner-1·5 om.	3 very faint zones.
Sporulation.	Very poor.	Good.	Poor.	Good.
Range of size of spores in μ.	28×4·2.	11·2×5·6 to 42×11·2.	28×14	3·36×2·8 to 33·6×4·2.
Septation mode.	4-mode.	Spores muriform	3-mode.	Aseptate.
Other forms of spores.	Absent.	Absent.	Chlamydispores. First appear in the middle zone. Colour-Brussel's Brown Later all over.	Absent.
Saltations.	Absent.	...	...	...

Shape and character of spores :—

No. 6.—The spores are usually straight; the ends bluntly pointed; cells bulged out. They were vacuolate and 1- to 5-septate; and exhibit different forms of hypertrophy. (See figure 8.)

The spores of Nos. 7 and 9 did not develop any noteworthy character.

No. 10.—The spores were similar to those produced on Apple I, except that these were much longer. (See figure 9.)

4. Grape Decoction-Agar, No. I.

The grapes used were from Chaman and are well known in the Punjab and the U.P. and obtainable in Allahabad usually in the months of October and November. They are small, round, pale green, seedless and quite sweet. Average size about $1{\cdot}5 \times 1{\cdot}0$ cms.

Preparation.—

Ripe and sound grapes were selected for the experiment. A decoction was prepared by slow boiling and filtration as in the previous experiments. pH, 5. The formula is :—

Decoction of	30 grams of grapes.
Agar-agar	20 grams.
Distilled water	1000 c.c.

Range of temperature during the experiment.—25·6°C—28°C.

Graph 4 shows the course of the daily radial advance of the fungi on Grape I. There was a fairly good advance in the growth of all the fungi. They can be arranged in a descending order as follows: Nos. 7, 10, 9 and 6. The growth rate was fairly constant in No. 6. It experienced an alternating rise and fall at two occasions in Nos. 7 and 10. In No. 9, the growth rate gradually fell.

Macroscopic and microscopic characters

Characters.	No. 6.	No. 7.	No. 9.	No. 10.
Colour of the mycelium.	Pale Vinaceous Pink.	Dusky Olive Green.	Outer—Safrano Pink. Inner—Olive Brown.	Pale Vinaceous-Fawn
Colour of the substratum.	Absent.	Absent.	Absent.	Absent.
Development of the aerial mycelium.	Very poor.	Good.	Very Good	Very Poor.
Nature of the growth.	Non-staling.	Non-staling.	Non-staling.	Non-staling
Zonation.	Absent.	2 zones. Outer—·9 cm. Inner—1·6 cms.	2 zones Outer—·7 cm. Inner, —1·8 cms.	Absent
Sporulation.	Poor.	Very Good.	Very Good.	Very Good.
Range of size of spores in μ.	13·5 × 2·7 to 64·8 × 5·4	8·1 × 6·75 to 54 × 18·8.	16·2 × 10·8 to 24·4 × 16·2.	From less than 2·7 to 10·8 × 4·05.
Septation mode.	3-mode	Spores muriform.	3-mode.	Aseptate.
Other forms of spores.	Absent.	Absent.	Chlamydospores. Hyphae twisted.	Absent.
Saltations.	Absent.	...	...	...

Shape and character of spores:—

No. 6.—Spores mostly straight, rarely crescent-shaped; 2- to 8-septate; having many refractive globules and showing considerable hypertrophy. A special feature of the spores was their

prominent granularity in the cells, which were bulged out. In old cultures the granularity disappeared. (See figure 10.)

No. 7.—The spores here were similar to those on Brown's starch, in shape and other characters except that they exhibited a prominent granularity and very rough spore-coats. (See figure 11.)

No. 9.—No special character except granularity; they were similar to those on Brown's starch. (See figure 12.)

No. 10.—Similar to those on Brown's starch except for their prominent granularity in contents. (See fig. 13.)

5. Grape Decoction-Agar, No. II

Preparation.—

Sixty grams of grapes were used to have a medium of higher concentration than the previous medium, Grape I. The pH value was 4·6. The medium was prepared by the following formula :—

Decoction from ...	... 60 grams of grapes.
Agar-agar ...	... 20 grams.
Distilled water ...	... 1000 c.c.

Range of temperature during the experiment.—25·6°C —28°C.

Graph 5 shows that there was a steady rise in the rate of No. 6 except on the 5th day. The rate of No. 7 fell on the 7th day after a steady rise up to the 6th day. No. 9 showed a gradual fall all through and the rate of No. 10 gradually fell after the first rise on the 4th day. On the basis of average daily rate of radial advance, the four fungi can be arranged in this descending order: Nos. 7, 10, 9 and 6. This is similar to the results obtained on Grape I, but here the rates are higher.

Macroscopic and microscopic characters

Characters	No. 6	No. 7	No. 9	No. 10
Colour of the mycelium.	Vinaceous Pink.	3 colour regions. Outer—Vetiver green. Middle—Deep Olive. Inner—Dark Olive.	2 regions. Outer—Safrano Pink. Inner—Olive Brown.	Pale Vinaceous Fawn.
Colour of the substratum.	Shell Pink.	Absent.	Absent.	Absent.
Development of aerial mycelium.	Poor. (but better than Grape I.)	Good. (Better than Grape I.)	Very Good. (Better than Grape I.)	Very Good.
Nature of growth.	Non-staling.	Non-staling.	Non-staling.	Non-staling
Zonation.	Absent.	3 zones. Outer—·6 cm. Middle—1 cm. Inner—·7 cm.	2 zones. Outer—·7 cm. Inner—1·8 cm	Absent.
Sporulation.	Not Good.	Very Good.	Very Good.	Very Good.
Range of size of spores in μ.	13·5 × 2·7 to 64·8 × 5·4	8·1 × 6·75 to 54 × 10·8	13·2 × 10·8 to 24·3 × 16·2	From less than 2·7 to 10·8 × 4·05
Septation mode.	3-mode.	Spores muriform.	3-mode.	Aseptate.
Other forms of spores.	Absent.	Absent.	Chlamydospores in patches.	Absent.
Saltations.	Absent.	Absent.	Absent.	Absent.

Shape and character of spores :—

The shape of spores and their characters did not show any marked difference from those of Grape I.

6. Ripe Guava Decoction-Agar, No. I

The guavas were obtained fresh from one of the local gardens. The skin had turned quite yellow. Only sound fruits were used.

Average size:—9 x 7 cms.

Preparation.—

The skin was peeled off and the inner central portion, containing mostly seeds, was rejected. Only the pulp was used to prepare the decoction. pH, 4·4. The formula is :—

Decoction from	... 200 grams of ripe guava.
Agar-agar ...	... 18 grams.
Distilled water	... 1000 c.c.

Range of temperature during experiment.—23°C—25°C.

Graph 6 shows that there was a general fall in the growth rates of all the fungi. Nos. 6, 7 and 10 showed alternate rise and fall in their rates while No. 9 showed a steady fall and thus resulting into a "stale culture." On the basis of average daily rate of radial advance, the four fungi can be arranged in this descending order: Nos. 7, 10, 6 and 9.

Macroscopic and microscopic characters

Characters	No. 6	No. 7	No. 9	No. 10
Colour of the mycelium.	Orange Pink.	Two olour zones. Outer—Buffy Olive. Inner.—Dark Olive.	Two colour zones. Outer—Tawny Olive. Inner—Saccardo's umber.	Pale Pinkish Buff.
Colour of the substratum.	Absent.	Absent.	Tawny.	Absent.
Development of the aerial mycelium.	Absent.	Good.	Very Good.	Good.

Characters	No. 6	No. 7	No. 9	No. 10
Nature of the growth.	Non-staling.	Non-staling.	Staling.	Non-staling.
Zonation.	Absent.	7 zones.	4 wavy zones.	Absent.
Sporulation.	Poor.	Good.	Poor.	Good.
Range of size of spores in μ.	$22{\cdot}4 \times 4{\cdot}2$ to $44{\cdot}8 \times 5{\cdot}6$.	$8{\cdot}4 \times 8{\cdot}4$ to $50{\cdot}4 \times 8{\cdot}4$.	$19{\cdot}6 \times 11{\cdot}2$ to 28×14.	From less than $2{\cdot}8$ to $14 \times 2{\cdot}8$
Septation mode.	3-mode.	Spores muriform.	3-mode.	Aseptate.
Other forms of spores.	Absent.	Absent.	Chlamydospores are present at the marginal region of the colony.	Absent.
Saltations.	Absent.	...	...	...

Shape and character of the spores:—

No. 6.—The spores were straight or crescent shaped, 2- to 4-septate generally; hyaline; the end cells bluntly pointed. The cells were vacuolate and exhibited bulging and other forms of hypertrophy. Some of the spores from the clumps show germination from their end cells. (See figure 15.)

No. 7.—The spores here did not exhibit any special character except a prominent roughness of the walls in a few. In other features, they resembled those on Brown's starch. (See figure 16.)

No. 9.—Spores of two distinct shapes; some straight and cylindrical, others curved and bulged.

No. 10.—Spores were similar to those obtained on Brown's starch.

7. Green Guava Decoction-Agar, No. II

Preparation.—

The guavas used in this experiment were similar to those used in the previous experiment, Guava I, except that they were green and semi-ripe. The medium was prepared exactly in the same way as Guava I. pH, 4·0. The formula is :—

Decoction from	... 200 grams of green guava.
Agar-agar	... 18 grams.
Distilled water	... 1000 c.c.

Range of temperature during the experiment.—23°C—25°C.

Graph 7 shows the course of the daily radial advance of the fungi on Guava II. No. 6 maintained practically a constant rate, while No. 7 and 10 showed an alternating rise and fall in their rates. No. 9 suffered a fall in its rate on the first 5 days and later it also showed an alternating rise and fall in its rate of daily growth. The average rate of radial advance was different on this medium from that on Guava I. The fungi stand in this descending order : Nos. 7, 10, 9 and 6. Here No. 9 showed a better average rate than No. 6. On Guava I it was *vice versa*.

Macroscopic and microscopic characters

Characters	No. 6	No. 7	No. 9	No. 10
Colour of the mycelium.	Orange-Pink	Two colour zones. Outer-Grayish Olive. Inner—Dark Olive.	Two colour zones. Outer-Cinnamon Buff. Inner-Saccardo's umber.	Pale Pinkish Buff.
Colour of the substratum.	Absent.	Absent.	Tawny.	Absent.

Characters	No. 6	No. 7	No. 9	No. 10
Development of the aerial mycelium.	Absent.	Good. (Better than in Guava I.)	Very Good.	Good.
Nature of the growth.	Non-staling.	Non-staling.	Non-staling.	Non-staling.
Zonation	Absent.	7 zones.	4 wavy zones.	Absent.
Sporulation.	Poor.	Good.	Poor.	Good.
Range of size of spores in μ.	22·4×4·2 to 44·8×5·6.	8·4×8·4 to 50·4×8·4.	19·6×11·2 to 28×14.	From less than 2·8 to 14×2·8.
Septation mode.	3-mode.	Spores muriform.	3-mode.	Aseptate.
Other forms of spores.	Absent.	Absent.	Chlamydospores at periphery.	Absent.
Saltations.	Absent.	..	...	...

Shape and character of spores :—

No difference could be detected between the spores on this medium and those developed on Guava I.

8. Banana Decoction-Agar

The bananas were obtained from the local market, where they were imported from Hajipur, Bihar. They are popularly known in the market as "chinia kela." The skin had turned completely yellow and they were firm and fragrant.

Average size, 10 × 2·5 cms.

Preparation.—

The skin of the bananas was peeled off and rejected, and 200 grams of the edible portion was weighed for the

preparation of the decoction in the same way as in previous experiments. pH, 4·4. The formula is :—

Decoction from	...	... 200 grams of banana.
Agar-agar	...	... 18 grams.
Distilled water	...	... 1000 c.c.

Range of temperature during experiment.—21·5°C – 23°C.

Graph 8 shows the course of the daily radial advance of the fungi on Banana. No. 6 showed a slight gradual fall in its daily rate, while No. 9 experienced a considerable fall. Nos. 7 and 10 each showed a rise and fall alternating with one another in their daily rates of growth. The best average rate of radial advance was obtained in No. 7 and the lowest in No. 9, while it was better in No. 10 than in No. 6.

Macroscopic and microscopic characters

Characters	No. 6	No. 7	No. 9	No. 10
Colour of the mycelium.	Venetian Pink.	Two regions. Outer—Deep Olive Grey. Central,—1 cm. Olivaceous Black (1).	Brownish Olive.	Pale Pinkish Buff.
Colour of the substratum.	Absent.	Absent.	Absent.	Absent.
Development of the aerial mycelium.	Absent.	Very good.	Good.	Best of all media.
Nature of the growth.	Non-staling.	Non-staling.	Staling	Non-staling
Zonation ...	Very faint.	7 faint zones.	Absent.	Absent.
Sporulation	Very good.	Good.	Poor.	Very good.
Range of size of spores in microns.	19·6 × 4·2 to 50·4 × 5·6.	11·2 × 5·6 to 47·6 × 12·6.	25·2 × 12·6.	From less than 2·8 to 14 × 2·8.

Characters	No. 6	No. 7	No. 9	No. 10
Septation mode.	3-mode	Spores muriform.	3-mode	Aseptate
Other forms of spores.	Absent	Absent	Chlamydospores in abundance on the substratum	Absent
Saltations	Present	Absent	Present	Absent

Shape and character of spores :—

No. 6.—The spores were straight or curved ; the end cells either pointed or blunt, the latter more common. 2- to 5-septate ; highly vacuolate and the cells somewhat bulged out laterally; hypertrophy rare. The end cells germinate into a hypha. Some of the spores were joined in pairs, by a hyphal process, given out by one of the cells of the spores, a sort of H-connection being formed, and reminding one of conjugation. The significance of this was not clear. (See figure 17.)

No. 7.—Spores similar to those described on Brown's starch except that the walls here were smooth, and most of the spores transversely divided.

The production of colour was a distinct feature of this medium excepting the case of No. 10.

Saltations.—

In No. 6. they appeared on the 8th day of the culture and grew faster than the parent colony. (See figure 18.)

The distinctive characters of the saltants were:—

Characters	Parent	Saltant
Colour of the aerial mycelium.	Venetian Pink.	Pale Pinkish Buff.
Development of the mycelium.	Absent.	Good development.
Sporulation.	Very good.	More profuse.
Shape of spores.	Curved or straight, bluntly pointed, vacuolate, cells bulged and atrophied.	Cells are not atrophied. Sharply pointed, straight and non-vacuolate. (See figure 19.)
Septation mode.	3-mode	5-mode.

Distinctive characters of the saltant of No. 9 and its parent.

Characters	Parent	Saltant
Colour of the aerial mycelium.	Brownish Olive.	Deep Olive-Gray.
Sporulation.	Spores present.	Almost non-sporing.
Shape of the spores.	As described for Brown's starch.	More irregularity in shape.
Size of the spores.	$25{\cdot}2 \times 12{\cdot}6\ \mu$.	$47{\cdot}6 \times 5{\cdot}6\ \mu$.
Septation.	Uniformly 3-septate	Mostly 3. Rarely 4-septate. (See figure 21.)
Chlamydospores.	Present.	Absent, even when grown on Brown's starch.

A study of the chart here also shows that the saltant had characters quite distinct from those of the parent. Even the conservative structures, *e.g.*, the spores also exhibit changes.

9. Orange Juice-Agar

The oranges uesd in this experiment were from Gorakhpur, U.P. They were very sweet.

Average size : 5 × 6 cms.

Preparation.—

The oranges were peeled off, and the fibres were also removed from the skin of the segments, which were then weighed. It was easier here to extract the juice without boiling the segments, so they were cut open, crushed and filtered. pH, 4. 2. The formula is:—

Juice from	...	200 grams of orange pulp.
Agar-agar	...	18 grams.
Distilled water	...	1000 c.c.

The medium did not set, it remained permanently in a semi-solid state in the plates.

Range of temperature during the experiment.—22°C—24°C.

Graph 9 shows that the daily growth rate of No. 6 fell after a single rise within the first 6 days. No. 7 showed a daily fall up to the 6th day and then a rise. No. 9 showed a general fall in its rate after the 4th day and then again a rise and a fall in its rate of growth. On the basis of average daily rate of radial advance the four fungi can be arranged in this descending order : Nos. 10, 6, 7 and 9.

Macroscopic and microscopic characters

Characters.	No. 6	No. 7	No. 9	No. 10
Colour of the mycelium.	Tilleul-Buff.	Centre—Dark Olive. Outer—Yellowish Olive.	Dark Olive Gray.	Pale Pinkish Buff.

Characters	No. 6	No. 7	No. 9	No. 10.
Colour of the substratum.	Absent.	Absent.	Absent.	Absent.
Development of the mycelium.	Absent.	Good.	Very good.	Very good.
Nature of the growth.	Non-staling.	Non-staling.	Staling.	Non-staling.
Zonation.	Very faint.	6 zones, with 3 outer ones fainter.	Absent.	Two zones. Central — Loose mycelium. Outer—thick compact.
Sporulation	Poor	Good	Very poor	Good
Range of size of spores in microns.	16.8×4.2 to 42×5.6.	5.6×5.6 to 47.6×8.4.	22.4×11.2. 3-mode.	From less than 2.8 to 11.2×2.8.
Septation mode.	3-mode.	Spores muriform.	3-mode.	Aseptate.
Other forms of spores.	Absent.	Absent.	Chlamydospores in abundance.	Absent.
Saltations.	Absent.	Absent.	Present. Colour—Deep Gull Gray. Non-sporing.	...

10. Papaya Decoction-Agar

The papaya used in the experiment was obtained from one of the local gardens. The fruit was quite sound, ripe and firm. The skin had almost turned yellow; it was 15×10 cms. in size.

Preparation.—

The skin and the seed portions were removed and only the pulp was used for the preparation of the decoction. pH, 6·2. The formula is :—

Decoction from	... ...	200 grams of papaya.
Agar-agar	... ...	18 grams.
Distilled water	... ...	1000 c.c.

Range of temperature of experiment.—21·5°C—24°C.

Graph 10 shows that the rate of No. 6 first fell and then rose. No. 7 showed an alternating fall and rise. No. 9 showed a fall first and then rise and again a considerable fall in its rate of daily advance. No. 10 showed an alternating rise and fall in its rate. A uniformly good rate of growth of all the fungi was obtained on this medium. A series can be arranged in the descending order of the growth rates of the fungi : Nos. 10, 6, 9 and 7.

Macroscopic and microscopic characters

Characters	No. 6	No. 7	No. 9	No. 10
Colour of the mycelium.	Pale salmon colour.	Margin—Olive Buff. Colony—Dark Greenish Olive.	Margin—Pinkish Buff. Colony—Pale Olive-Grey.	Pale Pinkish Buff.
Colour of the substratum.	Absent.	Absent.	Slate-Grey.	Absent.
Development of aerial mycelium.	Absent.	Poor.	Good.	Good.
Nature of the growth.	Non-staling.	Non-staling.	Non-staling.	Non-staling
Zonation.	5 faint zones.	6 zones.	3 faint zones.	Absent.
Sporulation.	Poor.	Good.	Good.	Good.
Range of size of spores in μ.	22·4 × 4·2 to 44·8 × 5·6.	11·2 × 5·6 to 53·2 × 8·4.	25·2 × 11·2.	From less than 2·8 to 19·6 × 4·2.

Characters	No. 6	No. 7	No. 9	No. 10
Septation mode.	5-mode.	Spores muriform.	3-mode.	Aseptate
Other forms of spores.	Absent.	Absent.	Chlamydospores on substratum.	Absent.
Saltations ...	Present.	Absent.	...	...

Shape and character of spores :—

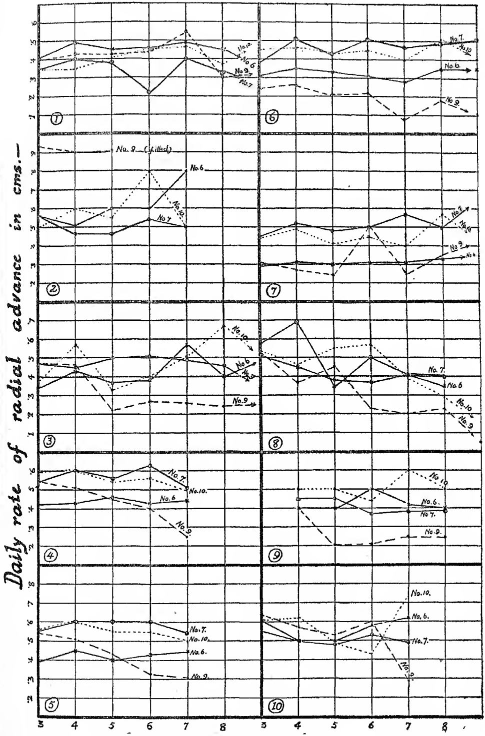
The spores were similar to those on Brown's starch in Nos. 6, 9 and 10.

No. 7.—Spores similar to those on Brown's starch, in addition to their thick walls, which exhibited very prominent surface roughness.

Papaya produced colour zones in Nos. 7 and 9. The colour of the substratum was developed only in No. 9. The results in the development of aerial mycelium were fairly satisfactory except in No. 6, a pionotal type. Zonation was indistinct, though common to all fungi except No. 10. The production of the spores was quite good in all the fungi, except No. 6, for which the medium proved poor in several other respects also. The septation mode in the parent rose to 5. The development of chlamydospores was similar to those of the other media. The medium also produced saltants in No. 6, which differed from the parent colony in the following characters :—

1. Colour ... ... Pale Pinkish Buff.
2. Mycelium ... Good development.
3. Septation mode ... 3.
4. Spores ... ... Smaller than the parent.

The medium on the whole is very good for the study of growth rates, sporulation, saltations and chlamydospores. Due to its low cost and simple method of preparation, it is the second best medium thus far met with in this work for the study of the fungi.


Daily rate of radial advance in cms.—
No. 9 (killed)
No. 6
No. 7
No. 9
No. 10
No. 10.
No. 6.
No. 7.
No. 9.
3
4
5
6
7
8

III. COMPARISON OF THE DIFFERENT MEDIA

Growth Rate.—

As seen from the table, the largest colonies were obtained on Apple I, *keeping in mind all the four fungi.* The second largest were those on Papaya.

The average rate of radial advance was calculated from 9-day old cultures. The following tables give the comparative rates of radial advance on the different media. All measurements are given in centimetres.

Growth rate of No. 6.—

	Medium.	Growth Rate.
1.	Apple I ...	... ·614
2.	Papaya ...	... ·56
3.	Brown's starch	... ·448
4.	Grape I ...	... ·44
5.	Banana ...	... ·437
6.	Grape II ...	... ·433
7.	Orange ...	... ·433
8.	Apple II ...	... ·424
9.	Guava I ...	... ·325
10.	Guava II ...	... ·314

Growth rate of No. 7.—

	Medium.	Growth Rate.
1. 2.	Grape I } Grape II } ...	... ·565
3.	Guava II ...	... ·523
4.	Papaya ...	... ·51
5.	Apple I ...	... ·506
6.	Banana ...	... ·491
7.	Guava I ...	... ·473
8.	Apple II ...	... ·46
9.	Orange ...	... ·41
10.	Brown's starch	... ·335

Growth rate of No. 9. —

	Medium.	Growth rate.
1.	Apple I ...	... ·913
2.	Papaya ...	... ·524
3.	Grape I ...	... ·481
4.	Grape II ...	... ·476
5.	Brown's starch	... ·410
6.	Guava II ...	... ·334
7.	Banana ...	... ·320
8.	Apple II ...	... ·310
9.	Orange ...	... ·262
10.	Guava I ...	... ·187

Growth rate of No. 10. —

	Medium.	Growth rate.
1.	Apple I ...	... ·59
2.	Papaya ...	... ·576
3.	Grape II ...	... ·541
4.	Grape I ...	... ·54
5.	Orange ...	... ·51
6.	Apple II ...	... ·48
7.	Guava II ...	... ·456
8.	Banana ...	... ·455
9.	Guava I ...	... ·443
10.	Brown's starch	... ·421

Taking into consideration all the characters it can be safely concluded that the rate of growth alone is no criterion of the value of a medium. The same has been also found by Mitra (16) working with the same four fungi. Stevens and Hall (8, p. 15) state that "no correlation is noted between the rapidity of linear growth and the nutritive value of the medium. In many instances most rapid linear growth occurred in what was surely the poorest medium."

Colour production.—

Attention was drawn in the account of the previous experiments to the fact that all the four fungi differ from one

another in colour production on the same medium. When grown on different media, a change in the intensity of the colour was noticed but the basic colours remained the same. The basic colours for the four fungi were :—

No. 6	...	...	... Pink.
No. 7	...	...	... Olive.
No. 9	...	...	... Brown.
No. 10	...	...	... Pink.

On the different media different shades of these colours were produced as shown in the chart given for each experiment. The greatest variability in colour was shown by Nos. 7 and 9, where the shade of even the basic colour was sometimes slightly different. These observations suggest that the presence of the basic colour on all the media is due to a factor for colour production inherently present in each fungus. The appearance of different shades of that basic colour would at once suggest the effect of the different media in bringing about these modifications. Hence it can be concluded that media are partially responsible for the production of colour in fungi. It may be stated here in a general way that the intensity of the colour of the aerial mycelium was observed to fade with the age of the culture, while the colour of the substratum intensified with age.

Development of the aerial mycelium.—

The development of the aerial mycelium on the different media may be classed as (*i*) luxuriant; (*ii*) good; (*iii*) poor; (*iv*) absent, and is shown below for the different fungi. They are arranged in a descending order :—

In No. 6.—

(*i*)	Luxuriant ...	...	on no media.
(*ii*)	Good ...	...	on no media.
(*iii*)	Poor ...	...	on Grape I and Grape II.
(*iv*)	Absent ...	...	on Apple I, Apple II, Guava I and II, Banana, Orange and Papaya.

This fungus is one of the pionotal forms of *Fusarium*, which do not develop any aerial mycelium.

In No. 7.—This fungus develops aerial mycelium on all the media.

(*i*) Luxuriant ... on Banana.
(*ii*) Good ... ... on Guava II, Grape II, Guava I, Grape I and Orange.
(*iii*) Poor ... ... on Apple II, Brown's starch, Papaya and Apple I.
(*iv*) Absent ... ... on no media.

In No. 9.—

(*i*) Luxuriant ... on Guava II, Guava I, Orange, Grape II, and Grape I.
(*ii*) Good ... ... on Papaya and Banana.
(*iii*) Poor ... ... on Brown's starch, Apple I & Apple II.
(*iv*) Absent ... on no media.

In this fungus luxuriant growth is obtained on 5 out of 10 media used.

In No. 10.—

(*i*) Luxuriant ... on Banana, Brown's starch and Orange.
(*ii*) Good ... ... on Guava II, Guava I, and Papaya.
(*iii*) Poor ... ... on Grape II, and Grape I.
(*iv*) Absent ... on Apple II and Apple I.

In respect to the development of aerial mycelium, taking into account all the four fungi, the media stand in the following descending order :

Banana, Guava II, Guava I, Orange, Grape II, Grape I, Brown's starch, Papaya, Apple II, and Apple I.

It was observed that the development of the aerial mycelium was better on media of higher than those of lower concentrations. These results are in agreement with those of Sawhney (13, p. 141), who states that, "the aerial mycelium is well developed in higher concentrations and diminishes in lower concentrations." However, this was not very well marked between Apple I and Apple II. It was also better on Guava II than on Guava I, showing that green guavas give better results than the ripe ones.

Nature of the growth.—

Nos. 6, 7 and 10 did not produce "stale cultures" on any of the media used. "Staling" growth was only observed in No. 9. With respect to this fungus, the media may be divided into two groups:

1. Non-staling ... Brown's starch, Apple I, Grape I and Grape II, Guava II and Papaya.
2. Staling ... Apple II, Guava I, Banana and Orange.

A comparison of these results with those of the development of the aerial mycelium in No. 9 will show that a good growth of aerial mycelium is associated with the "staling" media. The cause of "staling" is attributed by Brown (9) to the liberation of CO_2 and NH_3 in the metabolic processes. He says that these gases after diffusion are again absorbed by the medium at the growing margin of the colony, thus making it less suitable for growth. Balls (3) attributes the tendency of formation of aerial mycelium to the accumulation of poisonous excreta and thus the aerial hyphae return to the surface. The results obtained for No. 9 suggest that this fungus gives out much "staling products" in its growth. They are absorbed and accumulated at the margins of the growing regions. The hyphae instead of growing further, return to the surface and increase the bulk of the aerial mycelium. Thus in No. 9 there results an association of "staling".

Zonation.—

Some attribute zonation in colonies due to the alternating effect of light and darkness. This explanation is not supported by the experimental results in total darkness. The factor for producing zonation in the colony seems to be an inherent one, which is pronounced or suppressed according to the nature of the medium. In this work zonation varied even in the same fungus on differet media. The same medium also gave varying results for the different fungi. Similar results were also detained by Mitra (17).

Zonation in No. 6.—

(*i*) Papaya ... 5 faint zones.
(*ii*) Apple II ... 4 faint zones.
(*iii*) Apple I, Banana, and Orange. } Very faint zones; visible against light.

Zonation was completely absent from the colonies on other media.

Zonation in No. 7.—

In the following chart the media are arranged in the order of the number of zones they develop:—

Medium.	No. of Zones.	Colour Zones
1. Guava I ...	7, distinct ...	Outer—Buffy-Olive. Inner—Dark Olive.
2. Guava II ...	7, distinct ...	Outer—Grayish-Olive. Inner—Dark Olive.
3. Banana ...	7, distinct ...	Outer—Deep Olive Gray. Inner—Olivaceous Black (1).
4. Orange ...	6, distinct ...	Outer—Yellowish Olive. Inner—Dark Olive
5. Papaya ...	6, distinct ...	Outer—Olive Buff. Inner—Dark Greenish Olive.
6. & 7. Apple I and Apple II.	5, distinct ...	Colourless.

Medium.	Number of Zones.	Colour Zones.
8. Brown's ... starch.	4, faint ...	Outer—Pale Olive Buff. Inner—Dark Olive.
9. Grape II ...	3, distinct ...	Outer—Vetiver green. Middle—Deep Olive. Inner—Dark Olive.
10. Grape I ...	2, distinct ...	Outer—Buffy Olive. Inner—Dark Olive.

All the media, except Apple I, and Apple II, formed colour zones in this fungus. These colour zones were well marked from the growing zones.

Zonation in No. 9.—

Brown's starch, Banana and Orange did not develop zonate colonies in this fungus. The media are arranged below in descending order according to the number of zones:—

Medium.	Number of Zones.	Colour Zones.
1. Apple I ...	5, distinct ...	Colourless.
2. Guava I ...	4, distinct ...	Outer—Saccardo's umber. Inner—Tawny Olive.
3. Guava II ...	4, distinct ...	Outer—Cinnamon Buff. Inner—Tawny Olive.
4. Apple II ...	3, distinct ...	Colourless.
5. Papaya ...	3, distinct ...	Colourless.
6. Grape I ...	2, distinct ...	Outer—Safrano Pink. Inner—Olive Brown.
7. Grape II ...	2, distinct ...	Outer—Safrano Pink. Inner—Olive Brown.
8. Brown's starch 9. Banana and 10. Orange	None ...	Colourless.

On Guava I and Guava II the margins of the zones were wavy, giving the colony a floral shape. (Photo 6.)

Zonation in No. 10.—

None of the media used, form zonate colonies in this fungus. On Orange, only a faint zonation was formed. This was marked into two mycelial regions. The outer had compact mycelial growth and the inner was distinguished by the loose nature of the mycelium.

Sporulation.—

The following chart shows the position of the media according to abundance of spore-production in the four fungi:—

	No. 6	No. 7	No. 9	No. 10
Poor.—	Papaya, Brown's starch, Apple I & II, Grape I & II, Guava I & II, and Orange.		Orange, Brown's starch, Apple I & II, Guava I & II, and Banana.	
Good.—		Orange, Papaya, Brown's starch, Apple I & II, Banana, Guava I & II.	Papaya.	Papaya, Brown's starch Guava I & II, Apple II and Orange.
Very Good.	Banana.	Grape I & II.	Grape I Grape II.	Apple I. Grape I & II and Banana.

Taking all the four fungi into consideration, the media can be arranged in this descending order of spore-production:—

Grape I and Grape II, Banana, Papaya, Apple I. The rest of the media were almost equal in their spore-production.

Range of size of spores and chlamydospores.—

A change in the range of the size of spores was noticed on different media. Using length of spores as the basis, the range of the size of spores is given in different experiments. The largest spores in No. 10, were obtained on Apple II. The formation of chlamydospores was exclusively restricted to No. 9, (Figures 7 and 14). They were developed on all the media except Brown's starch. They usually developed after the 8th day of inoculation. In the beginning they arise on the surface of the substratum below the aerial mycelium and later spread all over the medium. On Grape I and II, distinct triangular patches of chlamydospores were developed at the periphery of the colonies (Photo 4). The hyphae of No. 9 were usually coiled, twisted and intertwined (Figure 5). This feature was the most pronounced in cultures on Brown's starch after 20 days. At certain places these hyphae were seen to form compact masses, having the appearance of sclerotia.

Septation mode.—

In this work, a change in the septation mode was observed on the media. This change was quite frequent and noticeable in No. 6. The septation mode was constantly 3 in No. 9. In No. 7, the spores being differently-shaped and muriform, no septation mode was calculated. The spores in No. 10 were aseptate uniformly. The following table shows the arrangement of media according to decreasing septation mode in No. 6:—

Medium	Septationmode	Medium	Septationmode
1. Brown's starch.	5.	2. Papaya.	5.
3. Apple I.	4.	4. Apple II.	3.
5. Others.	3.		

Shape and character of spores :—

The spores were compared with those on Brown's starch. They are described fully in the preceding pages, and only special features will be mentioned here.

The spores of No. 6 exhibited prominent granularity and refractive globules on Grape I and II. These features were also noted in the spores of other fungi on these media. No. 6 also exhibited bulging of cells, which feature was also present on Guava I and II, Banana, Orange and Apple II. On Guava I and II, this bulging of the cells was found to disappear with age. Wherever the cells were bulged out, crescent-shaped spores were rare.

The spores of No. 7 showed rough, indented spore-coats on Grape I and II, Orange and Papaya.

The spores of No. 9 were generally uniform in shape and features, but on Guava I and II, and Orange there were also straight and ellipsoidal spores in addition to the curved ones.

The spores of No. 10 were largest on Apple II; but no difference in their shapes and character could be noticed on any of the media.

Grape I and II had a tendency to produce granularity in the spores of all the fungi. (Figs. 10, 11, 12 and 13.)

Saltations.—

Saltations were observed on 4 out of the 10 media and in 2 out of the 4 fungi used. The best saltants were developed on Banana in Nos. 6 and 9 (Figs. 18 and 20). Next came Brown's starch, which also produced saltants in Nos. 6 and 9 (Photo 1 and 2). These were well developed and distinct. Papaya and Orange also produced saltants in Nos. 6 and 9 respectively. These were not as sharply defined as the preceding ones. All these saltants are fully described in connection with the different media. The cause of their development is not yet fully understood. Here it is fully evident that their formation is in some way connected with the nature of the medium, as they appear only on certain media and not on others. Grape I and II are recommended as media for cultural study of the fungi, if one wishes to avoid saltants.

Taking into account the development of important characters of the fungi, and the cost of preparation the author would recommend the media in the following order :—

1. Banana decoction-Agar ... ... Best.
2. Papaya decoction-Agar.
3. Grape decoction-Agar, No. 1.
4. Grape decoction-Agar, No. II.
5. Brown's starch-synthetic medium.
6. Green guava decoction-Agar, No. II.
7. Orange juice-Agar.
8. Apple decoction-Agar, No. I.
8. Apple decoction-Agar, No. II.
10. Ripe guava decoction-Agar, No. I ... Poorest.

IV. SUMMARY

1. Four Deuteromycetes (No. 6, *Fusarium* sp.; No. 7, *Macrosporium* sp.; No. 9, *Acrothecium* sp.; and No. 10, *Spicaria* sp.) were grown and their variations studied on ten natural media prepared from extracts of Apple, Grape, Guava, Banana, Orange and Papaya. All these media were acidic in reaction. Brown's starch was included for purposes of oomparison.

2. The best rates of growth were obtained on Apple I and Papaya and the poorest on Guava I and Orange.

3. Colour of myoelium varied more or less from one medium to another.

4. Development of aerial myoelium was better on media of higher concentrations than those of lower concentrations. It was also better on green Guava than on Ripe Guava. The best results are obtained on Banana and Guava and the poorest on Apple I and Papaya.

5. Best development of zonation was obtained on Guava I and II, and the poorest on Brown's starch, Banana and Orange.

6. The best sporulation was obtained on Grape I and II, and Banana, while the poorest was on Guava I and II, and Apple II.

7. Spores showed variations in oonstitution, shape, size and even septation mode on oertain media, most on Banana.

8. The best saltations were on Banana and Brown's starch and the poorest on Papaya and Orange, while the rest of the media gave negative results.

9. Chlamydospores were produced abundantly on all the media except Brown's starch. They appeared in triangular patches at the periphery of the colonies on Grape I and II.

10. Because of low cost, ease of preparation and excellent development of the fungi on them, Banana, Papaya and Grape I and II are specially recommended.

In conclusion, the author acknowledges his indebtedness to Prof. J. H. Mitter for suggesting the problem and his guidance in this work, and to Mr. R. N. Tandon for his help in the preliminary mycological work.

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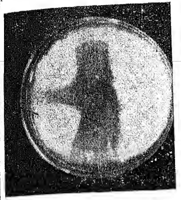
VI. EXPLANATION OF PHOTOGRAPHS & FIGURES

Photo.—

1. No. 6, showing saltations. The white regions represent the saltants having good mycelial growth, while the darker



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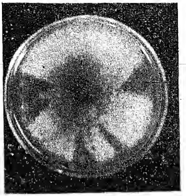

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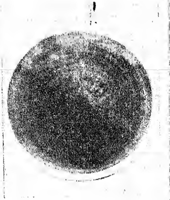

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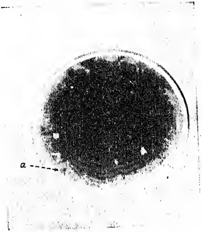

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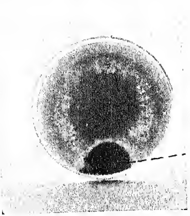

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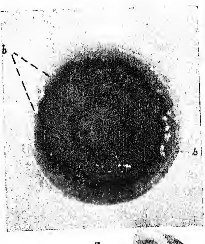

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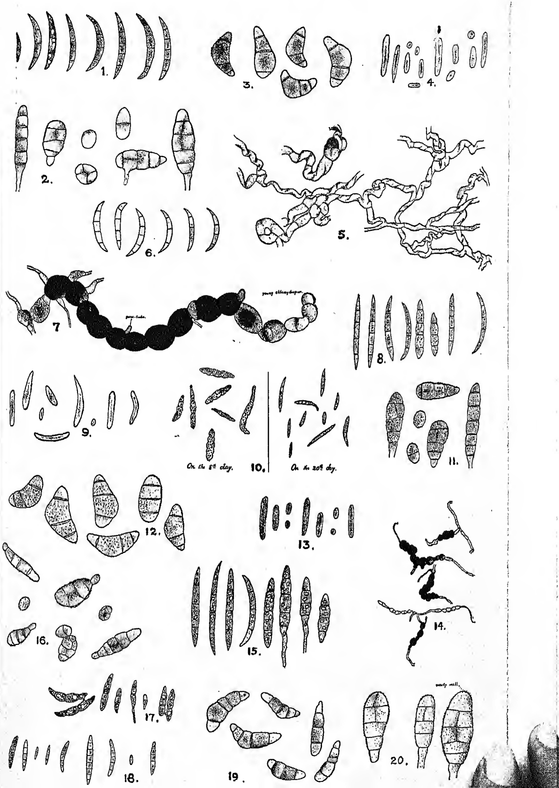
1.
3.
4.
2.
5.
6.
7
young chlamydospore.
8.
9.
On the 5th day.
10.
On the 20th day.
11.
12.
13.
14.
16.
15.
17.
18.
19.
20.

region is the parent, which is pionotal type. On the whole the saltants are seen to occupy more area than the parent colony.

2. No. 9, showing saltations in the colony at the periphery. Five dark sectors represent the saltants, while the parent colony is seen to occupy more area.
3. No. 7, on Apple I, showing zonation in the colony. Light and dark zones can be seen alternating with one another.
4. No. 9 on Grape I is seen to develop distinct triangular patches, a, at the periphery. These are regions of chlamydospores. The fungal colony is also seen to show wavy zonation.
5. No. 9 on Guava I is seen to show its "staling" nature of growth. The development of aerial mycelium is less here than that shown in Photo 6.
6. No. 9 on Guava II is seen to show its "staling" nature of growth. The development of aerial mycelium is shown better than in Photo 5. It is also seen to show a floral shape of its colony.
7. No. 9 on Orange is seen to show broad wavy zones and saltants, b.

Figures.—

1. Spores of No. 6 on Brown's starch.
2. Spores of No. 7 on Brown's starch. The wall of one is shown warty.
3. Spores of No. 9 on Brown's starch.
4. Spores of No. 10 on Brown's starch.
5. No. 9 on Brown's starch, showing the nature of the mycelium, which is peculiarly coiled, twisted and intertwined.
6. Spores of No. 6 on Apple I.
7. No. 9 on Apple I, showing a chain of chlamydospores at various stages of their development.
8. Spores of No. 6 on Apple II.
9. Spores of No. 10 on Apple II. They were hyaline and very slightly granular in the middle.
10. No. 6 on Grape I, showing granular and vacuolate nature of spores on the 8th day. On the 20th day they change their shape and nature as shown.

11. Spores of No. 7 on Grape I, showing the granular nature.
12. Spores of No. 9 on Grape I, showing the granular nature.
13. Spores of No. 10 on Grape I, showing the granular nature.
14. No. 9 on Grape I, showing chains of chlamydospores at various stages of their development.
15. Spores of No. 6. on Guava I, showing the vacuolate nature. Two of the spores are seen to germinate by their end cells.
16. Spores of No. 7 on Guava I, showing warty walls.
17. Spores of No. 6 on Banana. Two pairs are seen to be joined, reminding one of "conjugation". One spore is seen to germinate by its end cell.
18. Spores of Saltant of No. 6 on Banana.
19. Spores of Saltant of No. 9 on Banana. Some of the 4-septate spores are also shown.
20. Spores of No. 7 on Papaya, showing the characteristic warty walls of the spores.

SECTION II—Contd.

ZOOLOGY

NOTES ON TREMATODE PARASITES OF INDIAN BIRDS

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INTRODUCTION

The material which forms the subject of this communication consists mainly of the author's own collection, extending over a period of over four shooting seasons in the United Provinces and the collection lent by the Tropical School of Medicine Calcutta and the Zoological Survey of India. For this I express my deep indebtedness to Dr. Baini Prashad, Director of the Indian Zoological Survey and to Dr. P. A. Maplestone, Officer in charge, Hookworm Research Laboratory. My best thanks are also due to Dr. B. Mirza, Director Zoological Laboratories, Muslim University, Mr. Lachmi Sahai Veterinary Research Officer Behar, Mr. Dharam Narain, Professor of Biology, Kayasth Pathshala College, and Prof. M. A. Moghe of the College of Science Nagpur for some valuable material. I am also grateful to those friends who did a lot of shooting for me here, in Bengal and in Orissa.

The intention of the author was to bring out a monograph on the Trematodes parasites of North India with special reference to water and Shore Birds and this is in course of prepaation. But, recently, with the growing knowledge of forms made available, other workers in the country have also started working on the same forms.

Therefore, the present paper is in the nature of a preliminary report giving sufficient details of such forms as have already been worked up. This is intended to save my four years labour and also to facilitate the work of such others who may feel interested in the study of these parasites. The original paper with figures of forms mentioned here will soon follow in parts.

In the end I wish to convey my gratitude to Dr. D. R. Bhattacharya, Head of the Department for his ready help and guidance in this work.

Family ECHINOSTOMATIDAE Poche, 1926.

Genus I. ECHINOSTOMA Rudolphi, 1809

Four forms of the genus, Echinostoma, have been collected and studied from four different hosts, and brief notes about all of them are given here.

1. *Echinostoma bhattacharyai* n. sp.

Description.—Body elongated, spiny, sides nearly parallel, both ends rounded, broadest in region of acetabulum; size $5{\cdot}7 \times 1{\cdot}05$: head collar, $0{\cdot}3 \times 0{\cdot}463$, with 35 spines, 5 on each side form the ventral end group, 4 or 5 are laterally placed, the rest in uninterrupted double row, along dorsal side; end spines and dorsal spines of nearly same size, $0{\cdot}050 \times 0{\cdot}0168$; oral sucker subterminal $0{\cdot}185 \times 0{\cdot}235$; prepharynx short: oesophagus slightly longer than collar $0{\cdot}336$: ventral sucker in anterior fifth of body, $0{\cdot}924$ distant from front end, large, circular $0{\cdot}713 \times 0{\cdot}798$: cirrus sac short, antero-dorsal to acetabulum, seminal vesicle elongated, and cirrus curved; genital pore between sucker margin and intestinal fork; caeca reach near posterior end: ovary transversely

oval, nearly equatorial, $0{\cdot}134 \times 0{\cdot}18$, about $1{\cdot}0$ behind acetabulum, median: shell gland mass larger than ovary, between it and first testis: anterior testis $3{\cdot}07$ behind anterior end, margins irregular, ovoidal in outline; size $0{\cdot}463 \times 0{\cdot}302$; posterior testis more elongated and separated from the anterior by $0{\cdot}50$, size $0{\cdot}506 \times 0{\cdot}285$, shape elongated oval, margin feebly rugose: post testicular space $1{\cdot}6$: vitellaria lateral, partly or entirely overlapping caeca, from behind acetabulum to near end of caeca: uterus coils from shell glands to ventral sucker, walls indistinct; eggs about 25, operculated, large, $0{\cdot}091 - 0{\cdot}1092 \times 0{\cdot}067$—$0{\cdot}072$ in size. In small intestine of black-winged stilt, Mainpuri: U.P.

The above species differs from all those with same or nearly same number of collar spines, in the relative position and sizes of the various internal organs, and hence designated after the Head of the Department, as a token of gratitude for his ever ready and ungrudging help.

2. *Echinostoma crecci* n. sp.

Description.—Body elongated, flattened, minute spines detected over anterior half; anterior end slightly more tapering than posterior, broadest in the region of the ovary; size in life varied from $5-8 \times 1-1{\cdot}25$, on fixation $8{\cdot}8 \times 1{\cdot}4$: head collar $0{\cdot}3 \times 0{\cdot}506$, with 32 spines, 4 in each ventral end group, $0{\cdot}058 \times 0{\cdot}025$ larger and stouter than others $0{\cdot}039 \times 0{\cdot}016$; the arrangement in two rows seen in case of some dorsal ones only: oral sucker nearly terminal, $0{\cdot}144 \times 0{\cdot}21$: prepharynx short: pharynx $0{\cdot}135 \times 0{\cdot}143$: oesophagus long $0{\cdot}58$, and broader than caeca: ventral sucker in anterior fourth of body, $1{\cdot}275$ distant from nearest end, prominent, circular, $0{\cdot}638 \times 0{\cdot}705$: cirrus sac along anterior border of acetabulum, seminal vesicle prominent at base, cirrus convoluted; genital pore to one side of

median line, between sucker and intestinal fork, ovary transversely ovoidal, 0.27×0.336, on equatorial line, 2·5 behind acetabulum : oviduct distinctly seen arising from its middle : shell gland mass larger than ovary, partly overlapping it : testes roundish with irregular margin; anterior $0.59 - 0.44$ close behind shell gland; posterior 0.555×0.42 nearly 0·16 behind anterior : post testicular space 2·68 : vitellaria from about 0·75 behind acetabulum to posterior end, lateral, overlapping caeca here and there up to second testis, behind it run in and meet one another; follicles large, well developed : uterus long, coils between ovary and acetabulum, fills intervitellarial space; eggs numerous, large spindle-shaped, $0.1092 - 0.1176 \times 0.058 - 0.067$. In intestine of common teal, Allahabad.

The only species known to me with an equal number of collar spines is *Echinostomum govindum* Moghe, 1932, described from India, from another bird. But this is a comparatively larger form, and has a shorter forward reach of the vitellaria than the other Indian species, and also very distinctly different in other characters. Therefore it is named after its host.

3. *Echinostoma minimus* n. sp.

Description.—Body comparatively small 5.0×0.9, without spines and with sides nearly parallel, excepting near the posterior end which is gradually tapering; anteriorly a neck with a broadly truncated collar : body broadest in region of acetabulum : head collar strongly muscular, well developed, 0.352×0.506; spines on dorsal surface in two rows, 0.0624×0.0168; number uncertain owing to some having dropped; oral sucker terminal with mouth opening ventro-terminal, 0.21×0.24 : prepharynx nearly equal to pharynx, 0.168×0.185 : oesophagus, 0·51 long and about twice as broad as intestinal caeca : ventral sucker, $0.67 \times$

0·63, goblet-shaped, with thick muscular walls; at one third body length from head end: cirrus sac oval, 0·336 long, partly overlapping acetabulum: genital pore at level of intestinal bifurcation, median: ovary and testes all roundish, subglobular, equidistant from one another: ovary 0·165 in diameter, 1·25 behind ventral sucker, clearly behind middle length of body: shell gland about as big as ovary, overlapping it in part: anterior testis $0{\cdot}36 \times 0{\cdot}30$, posterior but slightly longer, post testicular space 1·4: vitellaria follicles small, rounded, never crowding much; from behind acetabulum to 0·37 ahead of hind end, strictly confined to lateral field, occasionally overlapping cacea but never extending much inwards: uterus between ovary and ventral sucker, intercaecal; eggs broadly oval about 50 in all, $0{\cdot}1176 - 0{\cdot}126 \times 0{\cdot}062 - 0{\cdot}067$: excretory bladder distinctly seen, in mounted specimen extending to posterior testis and bifurcating; it appears four-chambered; pore subterminal. In intestine of Black Swan, Patna, Behar.

Leaving aside the number of collar spines to be determined when more material is available, in its non-spiny cuticle, in its smaller size of vitelline follicles restricted to a narrow belt, and in the particular shape and comparatively smaller dimensions of its reproductive glands, it combines characters which distinguish it from forms like *E. Columbae* Zunker, 1925, which has much smaller eggs, *E. academica* Skrjabin, 1915, which is spiny and about twice as big, E. *exile* Lutz, 1924, which is also spiny and has a large number of eggs. *E. australasianum* Nicoll, 1914 (1915) and the allied *E. hilliferum* Nicoll which differ in peculiar shape of posterior testes in half twists, and considerably larger body size, and *E. corvi* Yamaguti, 1934 a much more stoutly built form with testes overlapping, numerous eggs and scale-like spines. Therefore I am certain that the form is new.

4. *Echinostoma longicirrus* n. sp.

Description.—Body thin, elongated, neck region with margins ventrally curled, and neck often bent at an angle to posterior body, broadest in region of acetabulum, scale like cuticular spines, on neck more close, visible up to region of ovary; size $5-7 \times 0{\cdot}9-1{\cdot}2$: collar more or less of same form and size as in *E. minimus* n. sp., head spines 34, in two alternating rows, differing in size from one another; larger ones $0{\cdot}057 \times 0{\cdot}0165$, smaller about two-thirds as long; end group of 3 spines: oral sucker $0{\cdot}18 \times 0{\cdot}21$; prepharynx a little longer than oral sucker: pharynx smaller than oral sucker: œsophagus long, not thicker than intestinal forks, 0·5 long: ventral sucker $0{\cdot}45-0{\cdot}56$ in diameter nearly one third body length from head end: cirrus sac conical, small, only partly overlapped by acetabulum; one specimen with cirrus exserted, very long $0{\cdot}34 \times 0{\cdot}025$: ovary round, small, behind middle of body, or nearly equatorial, 0·15 in diameter, midway between acetabulum and anterior testis: testes proportionately large, anterior subquadrate, posterior elongate, conical in outline, each testis twice as long and broad as ovary: vitellaria from level of hind margin of acetabulum to near posterior end, lateral up to hind testis, but approach one another behind; follicles large, dense: uterus short with few eggs, in one specimen only four, in the other larger one none: excretory bladder in the larger specimens appears two-chambered: pore ventroterminal, bladder leading into it by a narrow tube. In intestine of Mute Swan, Patna, Behar.

As the two specimens on which the above description is based are both curved, they have been left to soften in alcohol glycerine, so as to straighten them for fuller study. Therefore this species is only provisionally considered new, because of the few eggs and the two-chambered excretory bladder.

Genus II. ECHINOPARYPHIUM Dietz, 1909

Four forms of this genus also have been so far collected and studied.

5. *Echinoparyphium recurvatum* variety *indiana*, n. var.

Description.—Several specimens of this characteristically curved form were obtained from common snipe, and a few also from a brahmany duck. They body has the characteristic shape, bent over itself from behind ventral sucker, with the lateral margins of the neck curled ventrally. In the variable shape of its testes and the varying sizes of its spines noted by different writers like Dietz 1909, Skrajabin 1915, and Yamagnti 1933, the specimens for different hosts and countries show sufficient range of variability. Even the body size has been stated to vary from 2·8 to 4·7. Only the number of collar spines is constant, namely 45.

The size of my specimens comes within the range indicated above, but in its much larger cirrus sac, 0·42, (instead of 0·24 – 0·25 described for the parent species), which reaches to near posterior border of testes, and the comparatively larger size of the pharynx $0{\cdot}126 \times 0{\cdot}08$, instead of 0·063, and other minor features I consider my form to be a new variety.

The full details of this are not given because of another closely similar form in which the number of spines on collar appear 47 instead of 45, obtained from one of the snipes. The latter is a species still under enquiry.

6. *Echinoparyphium splendens* n. sp.

Description.—Body elongated, stout looking, $13{\cdot}76 \times 2{\cdot}5$ just behind acetabulum: head collar $0{\cdot}6 \times 0{\cdot}9$, with 37 spines; 5 in each end group, stouter $0{\cdot}084 \times 0{\cdot}0336$, those along lateral and dorsal aspects in two rows of equal

length, $0 \cdot 1092 \times 0 \cdot 0252$: prepharynx very short : oesophagus broadens posteriorly : ventral sucker 1·38 behind head end, very large $1 \cdot 428 \times 1 \cdot 38$; cirrus sac about 1·0 long and half as thick, though lies in mounted specimen along anterior margin of acetabulum, it is not its natural position : genital pore to one side of median line : vitellaria as characteristic of genus, from near posterior end to some distance behind acetabulum; follicles dense and large, but those of two sides not quite touching each other, even behind testes : ovary nearly in middle length of body, ovoid, transverse, slightly to one side of median line, $0 \cdot 435 \times 0 \cdot 629$: uterus extends to behind shell gland, but main coils from ovary to sucker, with numerous eggs; testes regularly oval with smooth margins; anterior $0 \cdot 67 \times 0 \cdot 629$ near one third body length from hind end; posterior $1 \cdot 26 \times 0 \cdot 506$ separated from anterior by a short gap of 0·27, and larger than anterior : post-testicular space 3·44 : eggs numerous $0 \cdot 1176 \times 0 \cdot 0756$ in average size. In intestine of crows (rare).

This species is based on a single specimen obtained from about 100 house and jungle crows shot during two years by Mr. M. N. Datta. I do not consider it coming within the allied genus *Echinostoma* because of its very large cirrus sac, as compared with the small cirrus sacs which characterise that genus and the regularly oval testes. The genera Echinostoma and Echinoparyphium are very similar and I think that they may be merged together, but I shall consider the question later in the final paper, if sufficient proof is forthcoming. It has the same number of collar spines as *Echinostoma ralli* Yamaguti 1934, but is much larger than it and very different type of cirrus sac. The form from Japanese crow, *Echinostomum corvi* Yamaguti, though nearly as big as the above species, has 47 collar spines. Of the *Echinoparyphium* species known to me only *E. aconiatum* Dietz, 1909, has 37 collar spines but that form is only 1·6 long, and very different

in other respects. Thus the species is designated as new.

7. *Echinoponyphium gizzardai* n. sp.

Description.—Body elongated, slender, neck concave with edges ventrally curved, $2{\cdot}855-3{\cdot}0 \times 0{\cdot}46-0{\cdot}55$ in region of testes; minute spines on another region: collar $0{\cdot}201 \times 0{\cdot}30$, with 22 spines, angular ones $0{\cdot}05 \times 0{\cdot}015$; of border ones, larger $0{\cdot}042 \times 0{\cdot}01$, smaller $0{\cdot}0252 \times 0{\cdot}09$: oral sucker nearly globular $0{\cdot}084 \times 0{\cdot}1008$: pharynx globular $0{\cdot}08$: oesophagus about as long as ventral sucker: ventral sucker $0{\cdot}336 \times 0{\cdot}293$, strongly muscular with deep cavity; in first fourth of body length: cirrus sac, $0{\cdot}252 \times 0{\cdot}168$, reaching posteriorly to middle of acetabulum; genital pore median on intestinal fork: uterus, short, between ovary and ventral sucker, intervitellarial, with few eggs $(13-20)$ large ovoid or nearly rounded $0{\cdot}0756 \times 0{\cdot}67$ or $0{\cdot}1008 \times 0{\cdot}071$: ovary subspherical, 0·143 in diameter, about middle of body; testes smooth-margined, regularly ovoid or oval; anterior $0{\cdot}2352 \times 0{\cdot}21$ roundish; posterior $0{\cdot}336 \times 0{\cdot}21$: post testicular space about 0·67: vitellaria from hind border of acetabulum to near posterior extremity, follicles large, usually transversely elongated, thick: excretory pore postero-terminal. In Gizzard of Black Sawn.

The form is certainly new among the described species of the genus because of the small number of its collar spines, and therefore given a new name. I have some doubts about its location but as the deta given for it, No. 19 of the Calcutta Tropical School of Medicine, contains this information I have to abide by it.

8. *Echinoparyphium* sp.

In another tube, No. 27 of the School of Tropical Medicine, Calcutta, are about half a dozen specimens

labelled from the intestine of the same host as the previously described species. Some of these have been mounted, and two of them appear quite different from the new species gizzardai, described above. Their main features are as follows:

Description.—Body small, elongated, neck region often ventrally arched over with curl sides. Collor of the usual type with 44 spines; 5 in end groups of which 3 are large $0{\cdot}067 \times 0{\cdot}0168$ and two ventral ones smaller $0{\cdot}042 \times 0{\cdot}01$, the lateral and dorsal ones $0{\cdot}0588 \times 0{\cdot}122$ appear to be arranged in couples: oral sucker $0{\cdot}1176$: ventral sucker at one-fourth to one-fifth of body, $0{\cdot}42 \times 0{\cdot}336$: uterus long, eggs about 30, large; oval ones $0{\cdot}756 \times 0{\cdot}588$; boat-shaped ones $0{\cdot}084 \times 0{\cdot}05$: ovary $0{\cdot}168 \times 0{\cdot}151$; testes large, anterior $0{\cdot}353 \times 0{\cdot}218$, posterior $0{\cdot}42 \times 0{\cdot}21$, with a gap of $0{\cdot}588$ behind: cirrus sac $0{\cdot}3$ long.

A second specimen mounted on the same slide, from the same tube shows only 33 spines, 4 in each of the end groups and only 25 border ones. That is why I do not give any definite name to the above species yet, as I suspect there may be more than one species in the tube; and I have not been able to straighten and examine the others so far.

Genus III. EUPARYPHIUM Dietz, 1900

9. *Euparyphium longitestis* n. sp.

Description.—Body very long, $10{\cdot}5-11{\cdot}7$, and broadest $1{\cdot}5-1{\cdot}7$ in testicular region: anterior part covered with minute spines both on ventral and dorsal surfaces: beyond acetabulum, spines decrease and found only ventrally: collar rather feebly developed, and spines, owing to specimens being rather thick, could not be counted. In the single straightened specimen examined in creosote they appeared to have been dropped. But, in spite of the invisibility or absence of collar spines the form, in its body shape and size, in the position of its ventral sucker

close to oral sucker, in its beautifully elongate-oval cirrus sac, the considerably elongated testes and the nature of its vitellaria it bears an unmistakable resemblance to the genus Euparyphium. It may be ascertained after examination of some more specimens, now in course of treatment, that it is entirely without collar spines. If so either the definition of the genus will have to be modified or the form raised to a new genus. The other measurements, as an average of three different sized individuals, are collar breadth 0·547; oral sucker 0·227 × 0·27 : prepharynx absent; pharynx 0·227 × 0·21 : oesophagus short, nearly as long as pharynx : ventral sucker, 1·007 × 0·925, prominent, goblet-shaped, very close to anterior end, 0·956 – 1·1 from the extremity : cirrus sac elongate, oval, 0·882 × 0·42, to near hind magin acetabulum : uterus, short, intercaecal between ovary and ventral sucker : ovary near first third of body length, 3·78 from front end, oblique, 0·336 × 0·252 : receptaculum seminis present, dorsal to shell gland which lies between ovary and anterior testis : testes very long, sinuous, with margins smooth, in middle third of body; anterior 1·06 × 0·4, posterior 1·05 – 1·07 × 0·46 : post testicular space 4·2 : intestinal caeca terminate at 0·336 from hind end, and vitellaria at 0·378 : vitellaria lateral, mostly extracaecal throughout their length, from behind acetabulum to near hind end of body : eggs oval, 0·1008 – 0·1092 × 0·067 – 0·0756. In intestine of Black Swan; Tube 19, Tropical School of Medicine, Calcutta.

Genus IV. MICROPARYPHIUM Dietz, 1909

Two species of this genus have been obtained, only one of which has been so far studied and included here.

10. *Microparyphium montei* n. sp.

Description.—Body elongated, stoutly built, broadly tapering at both ends; posterior end with a caudal process,

$7{\cdot}1-7{\cdot}6 \times 0{\cdot}67-0{\cdot}72$ in region of ovary: minute cuticular spines distinctly on neck region: collar feebly developed, two puffs alongside of oral sucker: collar spines not seen: oral sucker rounded 0·205 in diameter, prepharynx absent; pharynx $0{\cdot}134 \times 0{\cdot}117$: oesophagus very small 0·05 long: ventral sucker very large 0·64 in diameter, close to oral sucker; only $0{\cdot}67-0{\cdot}7$ behind anterior extremity: cirrus sac, small, pear-shaped, between instestinal fork and acetabulum; only posterior part of it overlapped by sucker in some preparations: ovary nearly ovoid, oblique, $0{\cdot}3024 \times 0{\cdot}252$, about middle length of body, 3·187 from front end: shell gland massive, posterior to ovary: testes lobed, in posterior half of body; anterior 5 or 6-lobed, $0{\cdot}67 \times 0{\cdot}46$, posterior more elongated, margin cleft at 3 or 4 places laterally, $0{\cdot}806 \times 0{\cdot}403$: intertesticular gap about 0·1: uterus long, broadly convoluted with many large eggs, 100 or more in number, $0{\cdot}1092 \times 0{\cdot}0756$ in average dimensions: vitellaria lateral, hardly reaching a little internal to caeca here and there. In intestine of kingfishers, Bengal.

This is the largest of known species of the genus Microparyphium. In its lobed nature of the testes it resembles, *M. capallae* Yamaguti 1935, but differs from it markedly in larger body size, in the more anteriorly placed cirrus sac, and a much short and less broad oesophagus. Therefore the species is considered new and named *montei*, after its collector, Mr. M. N. Datta, of the Indian Museum.

Genus V. PARYPHOSTOMUN Dietz, 1909

11. *Paryphostomum novum* n. sp.

Description.—Body elongated, broadest behind ventral sucker, $9{\cdot}7--10{\cdot}8 \times 1{\cdot}51-2{\cdot}44$; spiny cuticle: head collar well developed with a double row of rather stout-looking spines, 37 in number, 5 or 6 in end groups and rest marginal: the end group ones in specimens from wild duck, Anas

platyrhyncha, are in groups of 6, three ventral and three dorsal, but in specimens from bar-headed goose, Anser indicus, on one side they are 5 and on the other 6 : oral sucker 0·21 to 0·25 in diameter : prepharynx well developed : pharynx $0·17 \times 0·235$, that of specimen from duck a little bigger than that of specimen from goose : oesophagus 0·8 – 0·925 long : ventral sucker $0·8 \times 1·17$ (duck), 1·3 in diameter (goose) : distance from anterior and 1·5 – 1·76 : cirrus sac, transverse in mounted specmens, along front margin of acetabulum, 0·9 long, with coiled vesicula seminalis : ovary near middle length of body, 0·3 in diameter (duck), $0·4 \times 0·6$ (goose) ; testes more or less lobed, anterior $0·67 \times 0·4 - 0·6$; in that from duck more distinctly lobed than in that from goose ; posterior $0·6 - 1·3 \times 0·05 - 0·06$: post testicular space 3·2 – 3·4 : vitellaria from behind acetabulum to near hind end of body, meet behind testes : uterus with numerous light yellow eggs of large size, $0·1008 - 0·1176 \times 0·067 - 0·0756$. In intestine of ducks and geese, Allahabad.

According to the key of known species of the genus given by Gogate, 1934, the above species is distinctly new, having its collar spines in double row and 37 in number.

12. *Paryphostomum pentalobum* n. sp.

Description.—Longest and stoutest of all echimostomes in my collection. Body spiny, very long $18·5 \times 2·28$ (in uterine zone), anterior end rounded, posterior conical with a short vesicular projection : head collar $0·713 \times 0·966$ having 35 spines, the dorsal ones being clearly arranged in two rows, and the ventral end groups of a bunch of 6 spines each arranged in three couples of 2 each ; end spines $0·1092 \times 0·0336$, dorsal ones $0·084 - 0·091 \times 0·0252$: oral sucker $0·42 \times 0·5$: prepharynx short : oesophagus less than 2·0 long : ventral sucker, rounded, large $1·007 \times 1·175$, within one-fifth of body length from head end (3·02

distant); cirrus sac, in mounted specimen, transverse between intestinal fork and sucker, only partly overlapped by latter; vesicula saminalis bent over itself, cirrus and pars prostatica well developed: ovary transverse, oval, $0{\cdot}286 \times 0{\cdot}67$, at 9·07 from anterior extremity: testes both 5-lobed, each lobe having a smooth rounded outline, separated from one another by 0·27; anterior $0{\cdot}84 \times 0{\cdot}67$ and 11·75 behind head end; posterior $0{\cdot}924 \times 0{\cdot}67$ and 4·62 ahead of caudal end. Vitellaria from behind acetabulum, lateral up to hind testis, behind it run inwards and meet up to posterior extremity; follicles large, close set: uterus coils not so dense as in previous species and eggs also less numerous though large oval, $0{\cdot}1008 - 1092 \times 0{\cdot}0588 - 0{\cdot}71$. In intestine of snipes, Allahabad.

From the key of the species already referred to in the above described species, this form also comes in the same group as the above, namely, the one with collar spines in two rows, but in its still bigger size, and the close set end groups of collar spines, and other differences in internal anatomy, it differs from the new species *P. novum*, as well as other known forms. Therefore I name it as pentalobum, the 5-lobed character of its testes.

Genus VI. PATAGIFER Dietz, 1909

13. *Patagifer wesleyi* n. sp.

Description.—Body elongated, broadest in region of ventral sucker, gradually narrows down towards posterior end, $12{\cdot}1 \times 1{\cdot}8$: head collar with a wide dorsal notch, characteristic of the genus, and a much wider ventral notch: spines 30 or 31 on each side around collar edge in single row, dorsal and ventral spines of row smallest, gradually enlarge towards sides, but two end spines of ventral side large: collar size $0{\cdot}9 \times 1{\cdot}91$: larger of the ventralmost end spines 0.156×0.058, lateral ones 0.24—

0·27 × 0·055 – 0·067, smallest dorsal 0·03 × 0·016 broad; all peg-like: neck deeply concave with prominent acetabulum projecting into it: no spines on body surface: oral sucker subterminal, round, 0·17 – 0·201 in diameter; pharynx: elogate oval, about twice as long as oral sucker: oesophagus one and a half times as long as pharynx: ventral sucker very large, goblet-shaped, protruded beyond ventral surface, 1·175 × 1·26, close to anterior end: cirrus sac only partly overlaps the cirrus, vesicula seminalis thrown into 3 or 4 convolutions like a double S, genital pore midway between fork and sucker margin: ovary oblique 0·25 × 0·17, near: one-third body length from collar end: shell gland mass about twice the size of ovary: testes elongated with somewhat irregular outline, separated from one another by nearly same distance as separates the first testis from the ovary; anterior 0·73 × 0·34; posterior 0·084 × 0·25: post testicular space nearly equal to one-third of body length: uterine convolutions mid-intestinal, but not yet full of eggs: vitellaria lateral, only overlapping caeca from near acetabulum to hind end: intestinal caeca to near hind end: in the only mounted specimen the caeca of the two sides cross each other. This may have been brought about by flattening the specimen, although no curl on margins detected. In intestine of Curlew.

This form has its body end pointed like the Australian species of Johnston, 1916, *P. acuminatus* and *P. fraternus*, but both of them have a lesser number of collar spines, and a more ventrally placed ventral sucker in addition to other distinctions. The Japanese form, P. *parvispinosus* Yamaguti, 1933, has no cuticular spines, like the Indian fluke, is also readily distinguished by the different number and sizes of its collar spines, by the relatively different position of its ovary, and the different form of the testes. The Indian species is further distinguished by all known forms in having its pharynx larger than the oral sucker.

I therefore name it after my student, Mr. W. K. Wesley. who had collected this form for me from Fatehpur.

Genus VII. MESORCHIS Dietz, 1909

14. *Mesorchis pennanti* n. sp.

Description.—Body salender, long, posteriorly reduced, broadest in testicular zone. $7·5 \times 0·925$: collar $0·252 \times 0·336$ with spines of about $0·061 \times 0·0201$ along the lateral margins: the number of spines on each side appears to be 11, but owing to specimens having got macerated before they could be fixed, this number is not certain: oral sucker, 0·08 in diameter; pharynx $0·1 \times 0·08$; oesophagus 1·6 long; cirrus sac $0·134 \times 0·21$, oval, with anterior end broadly rounded, lying obliquely in front of acetabulum: ventral sucker 0·42, at 2·15 from anterior extremity: ovary $0·21 \times 0·29$ pear-shaped, to right of median line, distance from head end 2·9 : shell gland between ovary and testis; anterior testis $0·55 \times 0·88$, transversely quadrilateral, 0·67 behind acetabulum and 3·24 from collar end; posterior $0·86 \times 0·71$ roughly subtriangular or ovalish in outline: ovary and testes rather close together, all within 2·0 of one another; post testicular space 2·75; vitellaria fill post testicular region, and extend forwards laterally along testes to front margin of anterior testis; follicles thick, large: uterus, compact, short between anterior testes and acetabulum, eggs less than 100, not very large, $0·0756 - 0·08 \times 0·058$; broadly oval. Intestine of Indian Darter.

The species differs from all others in its generative glands lying closer to one another, and in the relative position of its testes, ovary, ventral sucker, and their sizes. The shape of the testes is not quite as characteristic of the genus *Mesorchis*, as of the genus *Monilifer*, but unlike the latter in some other respects. I therefore provisionally assign this form to the genus *Mesorchis*, hoping to get

better preserved material before finally deciding its position.

Genus VIII. HYPODAERIUM, Dietz, 1909

Two flukes resembling the forms included in the above-named genus have been obtained so far; one from a shoveller duck, shot by me at Mainpuri, and the other from a pintail, dissected at Allahabad. The latter is clearly referable to the genus *Hypodaerium* according to the key given by Dietz, 1910; but the former differs and I propose to place it in a new genus.

15. *Hypodaerium magnocirrusa*, n. sp.

Description.—Body elongated, 9·3 – 10·1, broadest about ventral sucker 1·75, after that of a nearly uniform width 1·34, to about hind end, where it narrows down somewhat: collar not very well developed, and spines not distinct, size $0{\cdot}42 - 0{\cdot}506 \times 0{\cdot}227 \times 0{\cdot}252$: cuticle of body spiny to near ovary: oral sucker $0{\cdot}218 \times 0{\cdot}269$; prepharynx short; pharynx $0{\cdot}168 \times 0{\cdot}185$: oesophagus reduced, shorter than pharynx: cirrus sac in one preparation extends straight to a short distance posterior to hind margin of acetabulum. With wavy vesicula seminalis, and a very long cirrus; in the other mounted specimen, cirrus has been displaced antero-laterally by the flattening of the sucker, and the cirrus is exserted and measures $0{\cdot}6 \times 0{\cdot}17$: ventral sucker very big, $1{\cdot}05 \times 1{\cdot}18$ and only 0·7 – 0·9 behind head end: ovary $0{\cdot}319 \times 0{\cdot}302$, and 3·68 from front extremity, or behind equator; shell gland, large, compact: both elongate oval, anterior more so: anterior testis $0{\cdot}672 \times 0{\cdot}336$, margin slightly notched at 2 or 3 places, 4·607 distant from front end; posterior, $0{\cdot}605 \times 0{\cdot}336$; testes and ovary separated from one another by nearly same distance, and all lie in middle third of body: vitellaria from behind ventral sucker, lateral, encroach internal to caeca only

behind hind testis, but never meet: uterus widely convoluted, inter caecal, between shell gland and acetabulum; eggs many, operculated, $0{\cdot}091-0{\cdot}11 \times 0{\cdot}058-0{\cdot}067$: excretory pore terminal. In intestine of Pin Tail. Allahabad.

By the nature of its cirrus sac, and large cirrus, comparatively more forward position of ventral sucker, shape, size and position of tests and collar it differs from all known species.

16. *Hypoderaeum mainpuria* n. sp.

Description.—Body closely resembles in form and general features, *H. conoideum* (Bloch. 1782), the European form from duck, as in Figure 17, Plate 12, of Dietz's valuable paper on Echinostomes of Birds, 1910. Anterior body thick cylindrical, broadly rounded, behind acetabulum flattened and rolled up in living specimens, posteriorly narrower: size $7{\cdot}0-7{\cdot}75 \times 0{\cdot}97-1{\cdot}3$ (in front of ventral sucker), near termination of intestinal caeca only 0·6 to 0·7 broad: collar very short and feebly developed, hardly marked off from the body in one mount: $0{\cdot}18 \times 0{\cdot}376$: spines very minute,* number not yet definitely known; broad scale-like cuticular spines arranged in rings round the collar, characterise the neck region, diminish rapidly behind ventral sucker, visible up to level of ovary: oral sucker subterminal, 0.156×0.21; pharynx $0.1-0{\cdot}118 \times 0{\cdot}84-0{\cdot}109$: oesophagus about twice as long as pharynx, narrow: intestinal caeca to near hind end: ventral sucker highly muscular, thick 0·7 to 0·88 in diameter, about $0{\cdot}67-0{\cdot}75$ distant from head end: cirrus sac about as long as ventral sucker; in pressed mounts it shifts

* Even on careful examination of the two mounted specimens which are all that I have of this form they were missed till to-day, but I am convinced of their existence, and will report of their exact number later, after demounting and destaining one preparation and examination in creosote.

from its dorsal position over acetabulum, to one side or anteriorly; vesicula seminalis long, winding, and strongly developed cirrus surrounded by prostatic cells : genital pore closely posterior to intestinal bifurcation : ovary transversely oval, $0{\cdot}21 \times 0{\cdot}3 - 0{\cdot}42$, in front part of second third of body : testes elongated, with faintly depressed margins at 3 to 5 places on each side, separated from one another; anterior $0{\cdot}65 - 0{\cdot}67 \times 0{\cdot}34 - 0{\cdot}42$, near middle of body; one-third in anterior half but two thirds behind equatorial line : posterior, $0{\cdot}6 - 0{\cdot}756 \times 0{\cdot}35 - 0{\cdot}365$: post testicular distance $2{\cdot}57 - 2{\cdot}60$: vitellaria from behind acetabulum to near end of caeca, extracaecal at first, then only partly overlap caeca, behind testes run inwards to near median line, even freely meeting here and there; follicles large thick : uterus between ovary and acetabulum, transversely coiled, with characteristically thin wall and oval eggs, 30 in one specimen, and about 125 in the other; size of eggs $0{\cdot}08 - 0{\cdot}0925 \times 0{\cdot}051 - 0{\cdot}067$ excretory bladder long, extending unbifurcated to posterior testis, vibratile cilia seen in longitudinal ducts, pore terminal. Intestine of Shoveller Duck.

Although closely resembling *H. conoideum*, as above stated, it is readily differentiated from it by the smaller size of its body and eggs, by the relative size and position of internal organs, and above all by the extension inwards to the median line of its post testicular vitelline follicles. Therefore it is given a new name, after my native town, Mainpuri, U.P., where I had obtained it.

Genus IX. CHAUNOCEPHALUS Dietz, 1909

Specimens of this interesting genus were found in a tube, mixed up with two of some Acanthocephalan parasite, kindly sent to me by the Director of the Indian Zoological Survey. These specimens are imperfect and not properly

preserved. They were collected from the intestine of black-necked stork.

For two seasons I tried in vain to collect fresh specimens of this parasite. However, last November my good friend, Mr. Sat Jiwan Verma, kindly sent me a sooty gull, which he had brought for me at great personal inconvenience. From this I got enough numbers of a representative of this genus, and one other form of fluke.

The following table gives some data about these two forms and about the one known species *C. ferox* (Rud.) :—

	C. ferox.	*From Indian Stork.*	*From Indian Gull.*
Length of body . .	5·5—8·0	7·45—8·8	4·41—7·25
Breadth of fore body .	2·3	3·0—4·0	3·0—3·5
Breadth of hind body .	0·7—1·0	0·8—1·0	0·7—1·0
Number, collar spines .	27	26	27
Size of ventral spines .	0·110—0·150 × 0·0204	0·168×0·038	0·126×0·036
Size of dorsal spines .	0·074—0·110 × 0·0204	0·109—0·12 × 0·02 (larger) 0·08—0·09 × 0·018 (smaller)	0·121—0·134 × 0·0165—0·017 0·0925—0·108 × 0·013—0·015
Size of large end spines	0·160—0·185 × 0·034	0·19—0·21 × 0·035—0·045	0·142—0·151 × 0·017—0·023
Size of eggs . .	0·089—0·092 × 0·053—0·057	0·1008—0·109 × 0·042—0·0588	0·067—0·084 × 0·042—0·05

Nicoll (1915) has recorded one specimen from Australia, which differed but slightly from *C. ferox*, its larger end spines approaching those of the Indian form from stork.

I feel that the Indian forms from Gull and Stork are one and the same and different from *Chaunocephalus ferox*,

in having their fore body always much broader than in the known species, and in having their dorsal spines alternately long and short. The difference in number of spines may be due to one having dropped out in the imperfect specimens available from the stork. The size of eggs, and the more stouter built of collar spines of the stork form may justify its being called a different variety. For the present I am describing in brief the features of the species from Gull alone.

17. *Chaunocephalus similiferox* n. sp.

Description.—Body divisible into a spiny dilated bulb-like anterior, and a non-spiny much narrower cylindrical part, joined by a middle portion somewhat broader than the candal port and containing the acetabulum and the principal reproductive organs. In some mounts the middle part is marked from the other two by constrictions on both sides. In others there is only one constriction at middle level of the ventral sucker.

Collar disc-like, antero-terminal, $0{\cdot}59-0{\cdot}67$ broad, with 27 long spines,* straight and pointed at outer end; ventral end groups of four, dorsal two being larger than the two ventral, four lateral ones on each side of about same size, the rest dorsal alternatingly large and small: oral sucker $0.21-0.23\times0.3-0.336$: pharynx smaller than oral sucker $0{\cdot}25$ in diameter: oesophagus very long extending to near acetabulum, broad with characteristic, short, sinuous lateral diverticula; intestinal caeca narrower to near hind end of tail part opening in terminal part of excretory bladder; ventral sucker at junction of fore and hind or middle part, $0{\cdot}506-0{\cdot}547$: cirrus sac very small, $0{\cdot}17-0{\cdot}2$, conical, in front of sucker; genital pore surrounded by a short sucker, between intestinal fork and acetabulum margin, leads into a short atruim into which

* Dimension's noted in the preceding Table are not repeated here.

open the male and female ducts: ovary close behind acetabulum, right-sided, pear-shaped in younger forms, ovoid or oval in older ones, oblique, $0{\cdot}4-0{\cdot}5 \times 0{\cdot}506-0{\cdot}58$; testes vary in shape and respective position, according to condition of development of uterus, either side by side, separated from the ovary by the conspicuous shell gland mass and associated structures, or somewhat obliquely one behind the other; anterior or right testis $0{\cdot}42-0{\cdot}46 \times 0{\cdot}292-0{\cdot}336$ or $0{\cdot}336 \times 0{\cdot}252$; posterior $0{\cdot}3-0{\cdot}336 \times 0{\cdot}21-0{\cdot}252$: shape irregularly oval, to elongate oval, or ovoidish, or subtriangular: uterus very compact, between the testes and the acetabulum, with many eggs.*

A complete description of this species is furnished in a paper to be published shortly.

Genus X. *PSEUDOECHINOCHASMUS* n. gen.

This genus is provisionally created for the other interesting forms of smaller flukes, met with in the duodenum of the same Sooty Gull, from which the Chaunocephalus species above described were obtained.

The parasites, in body form, apparently look like *Echinochasmus*, but continuity of collar spines across back, deeply lobed nature of testes and continuity of the venter across the ventral surface preclude the possibility of including them in that genus. According to the key given by Dietz, 1910, the only genus with similarly characterised, divided, testes usually transversely elongated is *Paryphostomum*. But the latter genus has the body form slender, posteriorly reduced, contrary to the posteriorly broad and shorter body form of these distomes. Moreover the arrangement of collar spines also is very different. Therefore, pending further study, I place it in the new genus, with the following notes about the type species.

* Dimension's noted in the preceding Table are not repeated here.

18. *Pseudoechinochasmus satjivani* n.g., n. sp.

Description.—Body short elongated, anteriorly narrower, posteriorly broadly rounded, $1{\cdot}8-2{\cdot}2 \times 0{\cdot}4-0{\cdot}6$, breadth from behind acetabulum more or less same: cuticular spines thick on neck: head collar broader than long $0{\cdot}15-0{\cdot}3$, united across venter, with 19 alternating dorsal spines of same length, 0·0336, 4 lateral ones on each side, of two sizes $0{\cdot}033 \times 0{\cdot}008$ or $0{\cdot}399 \times 0{\cdot}01006$; end groups of 5 spines each, four large $0{\cdot}0596 \times 0{\cdot}01596$, one small 0·0339 long: total number of collar spines 37: oral sucker 0·067; prepharynx 0·0252; pharynx $0{\cdot}067 \times 0{\cdot}05$; oesophagus $0{\cdot}14-0{\cdot}143$ long; ventral sucker within one fourth to one-fifth of body length from anterior end, $0{\cdot}32-0{\cdot}36$ in diameter: cirrus sac antero-dorsal to acetabulum, not extending beyond its middle; cirrus often everted, long, $0{\cdot}35-0{\cdot}42 \times 0{\cdot}067$: ovary roundish, feebly lobed or smooth margined, $0.13-0.14$ in diameter, to left of median line: shell gland mass along inner side of ovary: testes median close behind shell gland, separated from one another by same distance which intervenes between ovary and anterior testis, variable in shape and outline; anterior usually transversely elongated, $0{\cdot}181-0{\cdot}192 \times 0{\cdot}248-0{\cdot}225$, lobes five to seven, subdivided in some mounts, equatorial in position, $0.265-0.336 \times 0.252-0.263$; posterior immediately behind anterior, often subtriangular in outline with hind surface rounded; lobes three to five, subdivided or not: (the lobed condition is beautifully visible in those not pressed when fixed, and still more so in younger, though quite mature forms): vitellaria lateral, from anterior level of first testis to near hind end of body, behind testes approach one another to middle line: excretory bladder wide, bifurcates behind testes, cornua visible up to acetabulum in some preparations, pore terminal: uterine coils transverse, between anterior testis and acetabulum; eggs $30-40$, $0{\cdot}084-0{\cdot}0924 \times 0{\cdot}050-0{\cdot}0588$.

Genus XI. *DISSURUS* n. g.

About a dozen specimens of very thin elongated trematodes, collected and mounted by Mr. Dharam Narain, Professor of Zoology, in the local Kayasth Pathshala, were kindly handed over to me, for which I am deeply indebted to him. On careful study I find that they are closely allied to the genus *Himasthala* Dietz, in body form and general organisation, but in the much smaller size of their cirrus sac, in the more anteriorly placed ovary, and in the extent of their vitellaria these parasites show characteristics quite unlike those of that genus. Hence a new genus is proposed for them and named after the generic name of their host, *Dissura episcopa*, the white-necked stork.

This new genus displays other interesting characters and its relationship with other genera will be discussed in the fuller paper to follow, and the generic diagnosis also given.

19. *Dissurus farrukhabadi* n. g., n. sp.

Description.—Body long, very slender, delicate, 9·0 – 13·5, considerably attenuated between acetabulum and ovary 0·18 – 0·21; neck region subcylindrical, 0·35 – 0·38 broad; very gradually broadening behind ovary and ending in a rounded extremity; maximum breadth in region of testis, a short distance from posterior end, 0·6 – 0·8; cuticular spines with cleft base on anterior half easily discernible : collar reniform $0·25 – 0·336 \times 0·38 – 0·46$, spines 24 in one row, interrupted dorsally to mouth opening, no end group : innermost ventral $0·055 \times 0·0117$, largest lateral $0·062 \times 0·0199$, innermost dorsal $0·046 \times 0·0165$: oral sucker rounded, terminal, mouth ventro-terminal, 0·084 – 0·126; prepharynx as long as pharynx; pharynx $0·084 – 0·1 \times 0·067 \times 0.07$, oval : oesophagus thin, long 0.5 – 0.6 : intestinal caeca straight, to near hind end : ventral sucker nearly

round, 0.378 – 0.506 in mean diameter, at 0.97 – 1.05 from front end: cirrus sac, $0.21-0.23 \times 0.12$ short, conical anterodorsal to ventral sucker, not reaching posterior to its middle, seminal vesicle constricted in middle: ovary, rounded, $0{\cdot}21-0{\cdot}27 \times 0{\cdot}176-0{\cdot}198$, distance from head end 3·8 – 6·01, *i.e.*, behind one-third body length from anterior extremity; shell gland complex postero-lateral to ovary, sometimes partly overlapping it: testes elongate oval in form, margins rugose, in last third to fourth of body; anterior, $0{\cdot}66-0{\cdot}71 \times 0{\cdot}37-0{\cdot}4$, with 2 notches on each side, 2.2 – 3.36 behind ovary; post testicular distance 0·67 – 1·17; vitellaria from ovary to near end of caeca, follicles dense and continuous from side to side: uterus between ovary and acetabulum, inter-caecal, eggs less than 100, large oval, $0{\cdot}1-0{\cdot}118 \times 0{\cdot}05-0{\cdot}07$: excretory pore ventro-terminal. In intestine of White-necked Stork, from Farrukhabad, U.P.

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Family. STRIGEIDAE Railliet, 1919

Large numbers of representatives of this family were collected by me during the last four seasons, from United

Provinces, Behar, Bengal and Orissa, and some valuable material was also available from the collection of the Tropical School of Medicine, Calcutta. In these collections are representatives of only three of the five sub-families into which the family stands divided to-day. The sub-family *Alariinae* is very poorly represented, but *Polycotylinae* and *Strigeinae* are abundantly met with in Indian birds. So far no representative of *Cyathocotylniae* and *Brauninas* has been noticed by me.

Sub-Family. ALARUNAE Hall and Wigdor, 1918.

Genus I. ALARIA Schrank, 1788

1. *Alaria robusta* n. sp.

Description.—Fore body thick, oblongish or squarish, $1{\cdot}15-1{\cdot}175\times0{\cdot}8-1{\cdot}0$; hind body $0{\cdot}9-1{\cdot}09\times0{\cdot}67$ (testicular region), only 0·46 (bursa region): oral sucker $0{\cdot}1\times0.167$: pharynx smaller than oral sucker 0.084: acetabulum $0.547-0.55$ behind front end, $0.08-0.1$ in size; hold fast organ of two folds, separated by a median cleft, occupylng slightly more than three-fourths length of fore body; vitellaria confined to fore body, spreading all over it: ovary near junction of two body regions 0.21×0.35; followed closely by anterior testis, lying slightly to one side of median line, broader towards the outer end, 0.15×0.25; vitelline reservoir between the two testes and Mehlis' gland along postero-internal side of anterior testis: posterior testis 0.21×0.25: uterine coils extending into hind part of adhesive organ with about 10 eggs in that region, of size $0.092-0.109\times0.056-0.071$: terminal part of uterus and ductus ejaculatorius unite in a short common space leading into the genital atrium which opens postero-dorsally and has a heavy musculature surrounding it, size of genital atrium 0.336×0.42: vesicula seminalis coiled behind hind

testis. In small intestine of King Vulture. Allahabad District.

The species closely resembles *A. nasuae* La Rue and Townsend 1932; but differs from it in body size and position of Mehlis' gland, and the absence of cuticular spines, besides other characters. In its body size it approaches *A. pseudoclathrata* Krause, but has a different relative proportion of hind and fore body, a longer extent of the hold fast organ, and a larger size of its oral sucker. Therefore it is different from all known species.

Sub-Family. POLYCOTYLINAE, Monticelli, 1892.

Genus II. *PROCRASSIPHIALA* n. g.

A number of specimens obtained from the common Cuckoo and the Red-Wattled Lapwing (*Titeri*), though differing from one another, resemble in one respect, namely, the possession of a forebody somewhat shorter and thicker than that of the genera *Neodiphostomum* Railliet 1919, or *Proalaria* La Rue 1926: the margins of the fore body unlike that in these genera do not project beyond the surface, at the line of union. They do not even from the low urn or bowl characteristic of the G. *cassiphiala* Van Haitsma, 1925, nor do they possess any suckers on the dorsal surface as in G. *Polycotyle* Will-Suhm, 1870. Neither do they have their vitellaria extending over the fore body as in G. *Allodiplostomum scolopacis* Yamaguti, 1935. Therefore they are put into a new genus with the following distinctive characters :—

Polycotylinæ : Fore body thicker and relatively shorter, lateral magins joining at base do not project beyond surface, still division into two regions clear; no dorsal or accessory suckers, hold fast organ bulbous with a cavity : ventral sucker transversely elongated : vitellaria on both hind and fore body : uterus just enters hold fast organ.

2. *Procrassiphiala titricum* n. sp.

Description.—Fore body short, flat, but somewhat thick $0{\cdot}93 \times 0{\cdot}75$; hind body cylindrical $1{\cdot}26-1{\cdot}3 \times 0{\cdot}58-0{\cdot}75$: oral sucker 0·1 in diameter: pharynx smaller than oral sucker $0{\cdot}059 \times 0{\cdot}05$: oesophagus as long as pharynx: acetabulum transversely elongated, $0{\cdot}07-0{\cdot}14$, larger than oral sucker in transverse diameter, 0·3 behind oral end: hold fast organ bulbous with a cavity, margin papillated $0{\cdot}336 \times 0{\cdot}25-0{\cdot}29$: ovary $0{\cdot}09-0{\cdot}16$ behind line of junction of fore and hind body, oval, $0{\cdot}126 \times 0{\cdot}168$ in size: testes very large, nearly filling up the transverse direction of hind body and the space between genital atrium and ovary: anterior 0.67 long, on sides 0.42 broad, in middle constricted 0·16 wide; posterior 0·63 long, on sides 0·46 broad, middle constricted part as broad as in anterior. Vitellaria over greater part of hind body, thick in front of ovary, only on ventral surface behind it, and in fore body extend to region of oesophagus, leaving anterior and lateral areas free: genital atrium with muscular walls, postero-dorsal, $0{\cdot}17 \times 0{\cdot}21$; vesicula seminalis short, S-shaped between hind testis and atrium: uterus extends to hold fast region, just entering it; eggs up to 40 in one specimen, size $0{\cdot}1008-0{\cdot}1009 \times 0{\cdot}05-0{\cdot}058$. In intestine of Red-Wattled Lapwing.

3. *Procrassiphiala cuckooai* n. sp.

Description.—This is a slightly bigger form than the one from Lapwing and, in it the hind body is shorter than fore body, and hence testes more elongated: the hold fasts organ though bulbous has an entire margin. The details of measurements will be given later. Only two specimens were obtained from a number of cuckoos, examined at Allahabad, mixed up with another species of the genus Neodiplostum described hereafter.

Genus III. NEODIPLOSTOMUM Railliet 1919

Representatives of this genus have been obtained from Kestrel, Osprey, Vulture, Kingfishers, Cuckoo, Lapwing and Horn Bill, and include about half a dozen different species, of which only those that have been completely studied are mentioned here.

4. *Neodiplostomum globiferum*, n. sp.

Description.—Fore body $0{\cdot}547 \times 0{\cdot}38$, hind body $0{\cdot}38 \times 0{\cdot}42$: oral sucker $0{\cdot}084 \times 0{\cdot}1008$: pharynx a little shorter or about as big as oral sucker: oesophagus minute: intestinal caeca distinct: ventral sucker of same size as oral; hold fast organ oval to nearly rounded, with a central cavity, entire margins, touching acetabulum and nearly thrice as long as latter: margins of fore body laterally curled and meet just along posterior border of adhesive organ: ovary 0.1008×0.05, near junction of two body regions: testes very much attenuated in middle, dumb-bell shaped, with vitelline reservoir and Mehlis' gland between them; both of nearly same dimension 0·336 long; in middle 0·25 – 0·45 thick, along sides 0·126 thick: uterus just overlaps junction of hind and fore body: vitellaria in four strands in fore body, from behind pharynx to posterior testis in hind body; eggs few $0{\cdot}081 - 0{\cdot}084 \times 0{\cdot}058$: seminal vesicle coiled, thick, behind hind testis: genital atrium short, postero-dorsal, genital papilla in some specimens seen projecting into it. In intestine of Cuckoo.

In its characteristically short and globular hind body, and the peculiarly attenuated, dumb-bell shaped testes it is readily distinguished from the various species of the genus so far known.

5. *Neodiplostomum tytense* Patwardhan, 1935.

A number of specimens of a form closely resembling the above species were collected from Kestrel, and also

from Osprey and the common vulture. Neophron, mixed with other species. The specimens from vulture tally in measurements of body with those given by Patwardhan, except in the case of the hold fast organ which in my specimens measures $0{\cdot}4 \times 0{\cdot}23 - 0{\cdot}3$: the egg size is not given by the previous writer as his specimens were without them: there are 4 or 3 eggs only seen in my preparations and they measure $0{\cdot}101 - 0{\cdot}11 \times 0{\cdot}76 - 0{\cdot}84$.

But the specimens from Kestrel are 1·85 to 2·05 long, that is shorter than those of the species *N. tytense*, and the ratio in the fore and hind body is 1 : 1·1 instead of 1 : 1·2 in latter species, and vitellaria extend a little more forwards in the form from Kestrel. Therefore this may be a different species, but pending consideration of sections of this form which are not yet ready I reserve my final opinion.

6. *Neodiplostomum cochleare* (Krause, 1915)

A number of specimens of this worm were found in Tube 25 of the School of Tropical Medicine Collection, from the intestine of Horn Bill. The worms were fixed, in a relaxed state, in formalin and resemble very much in appearance and measurements given for it by Yamaguti 1935 [F. 15]. Though my measurements differ slightly from those of the Japanese examples, yet the two are decidedly the same. I give below some measurement of my forms for comparison. Fore body $1.6 - 1.8 \times 0.8 - 0.84$; hind body $0{\cdot}96 - 1{\cdot}05 \times 0{\cdot}46 - 0{\cdot}58$; oral sucker 0·084; acetabulum 0·101; hold fast organ $0{\cdot}42 - 0{\cdot}58 \times 0{\cdot}336 - 0{\cdot}42$: eggs $0{\cdot}1008 \times 0{\cdot}08$.

Genus IV. PSEUDODIPLOSTOMUM Yamaguti 1934

Two species of this genus both from the local Kingfishers have been collected. They differ from one another

and also from the allied Japanese species. I give below in tabular form the characteristics of these two new species and those of the Japanese one.

	P. cochleariforme, Yamaguti, 1934.	7. *P. cochlearis*, n.sp.	8. *P. fraterni*. n.sp.
Body length . .	2'0	0'65 – 0'72	1'207 – 1'22
Fore body L×B . .	0'625×0'4	0'21×0'134	0'331×0'21
Hind body L×B . .	1'38×0'27	0'47×0'15	0'88×0'38
Oral Sucker size . .	0'038×0'039: (subterminal).	0'047×0'033 (terminal, large, cup-shaped).	0'03 (small sub-terminal)
Pharynx size . .	0'03	0'0255	0'02
Oesophagus L . .	very short.	very short.	longer than oral sucker.
Acetabulum size . .	0'054 – 0'066 transversely elongate.	0'018×0'02 very small.	0'12×0'08
,, distance .	about middle.	about middle.	on margin of adhesive organ.
Hold fast organ size .	0'18×0'14 longitudinally elongate.	0'06×0'07 rounded.	0'08 rounded.
Ovary size . . .	0'084 spherical	0'04×0'05	0'074×0'095
,, position .	in front of testis.	a little ahead of testis.	in front of middle of hind body.
Testis 1 size L×B .	0'125×0'2 Bean-shaped.	0'1 – 0'11 (side view).	0'25×0'21
Testis 2 size L×B .	4'11×0'23 Bean-shaped.	0'1 – 0'12 (side view).	0'27×0'17
Position of testes .	in middle of last third.	behind middle of hind boy.	in middle third of hind body.
Eggs L×B . . .	0'091 – 0'095 × 0'066 – 0'069	0'093 – 0'0996 × 0'047 – 0'05	not present.
Host	Ceryle lugubris lugubris (Pied Kingfisher) Japanese.	Alcedo atthis (Common King-fiisher) Indian.	Ceryle rudis (Pied Kingfisher) Indian.

7. *Pseudodiplostomum cochlearis* n. sp.

The other characters not compared in the above table are as given for the genus by Yamaguti, 1934. Only in *P. cochlearis* the smallest form, the vitellaria are not so developed as in the other two: but it has the largest oral sucker, with its broad cup-like opening facing anteriorly. Its eggs are comparatively very big for the body size.

8. *Pseudodiplostomum fraterni* n. sp.

This is intermediate in size between the Japanese form, and its other allied Indian species. In its more forwardly placed ovary and testes, which latter are also quite voluminous, and the prominent vitellarian follicles, confined to the hind body, as characteristic of the genus, it is readily distinguished from the other two.

Genus V. ALLODIPLOSTOMUM Yamaguti, 1935

Only two specimens, of a form easily recognised to approach this genus, by its characteristic shape and position of the fore body, were found only once from the intestine of the Red-Wattled Lapwing, Allahabad. One of the specimens was cut up into sections to study the hold fast organ.

9. *Allodiplostomum hindustani* n. sp.

Description.—Body shape and relative position and size of fore body and hind body as characteristic of the genus. Hind body about twice as long as fore body, and about two-thirds as broad as long. Total length of body $0{\cdot}8-1{\cdot}25$ in life. Fore body in one mounted specimen $0{\cdot}21\times0{\cdot}25$; hind body $0{\cdot}42\times0{\cdot}3$: in sectioned material the fore body is 0.38 long and hind body 0.67 long : oral sucker directed forwards, 0.084 in diameter : pharynx 0.17 : aceta-

bulum near hold fast organ, 0.21 in diameter: hold fast organ, globular with lobed margin, projecting into the hollow of the cup-like body, though not protruding beyond the margin to the same extent as in the Japanese form: ovary 0·7 – 0·84, at extremity of first third of hind body: testes concave on ventral surface; tandem; in middle third of hind body: anterior 0·67 – 0·8 × 0·15 in size; posterior broader 0·1 × 0·22: shell gland mass along posterior, lateral border of anterior testis: vesicula seminalis S-shaped, behind posterior testis: genital atrium 0·1 in diameter, opening dorso-terminal: eggs not present. In intestine of Indian Red-Wattled Lapwing.

Genus VI. PROALARIA La Rue, 1926

10. *Proalaria alcedensis* Patwardhan, 1935

Numerous specimens of this species were obtained from both the common Kingfisher as well as the pied Kingfisher shot by me in 1933. The peculiar shape of the fore-body readily distinguishes this form from the new species of the Genus Pseudodiplostomum described above with which it resembles very much in general appearance. The measurements of my specimens, where they differ from those given by Patwardhan, 1935 are noted below.

Body length 1·62 – 1·76; fore body 0·46 × 0·34; hind body 1·2 – 1·34 × 0·3: oral sucker 0·03; ovary 0·1008; anterior testis 0·25 – 0·34 × 0·22 – 0·3; posterior 0·24 – 0·3 × 0·25.

11. *Proalaria grayii* n. sp.

Description.—Body length 0·75 – 1·07: fore body 0·45 – 0·637 × 0·21 – 0·27 in region of hold fast organ, about middle 0·17 – 0·21 broad: hind body 0·38 – 0·44 × 0·26 – 0·3: oral sucker, 0·02 in diameter: an accessory pit, with hair-like cilia projecting outwards, on margin of fore body a

short distance behind oral sucker: oesophagus absent: acetabulum $0{\cdot}3-0{\cdot}4$ in diameter, a little behind middle of fore body: hold fast organ a shallow, bean-shaped, transversely elongated pad-like structure $0{\cdot}07-0{\cdot}08 \times 0{\cdot}13-0{\cdot}18$: ovary just at junction of two body regions, $0{\cdot}05 \times 0{\cdot}07$ in size: testes large close behind ovary, overlapping one another in part, and the ovary, or just touching one another: anterior testis $0{\cdot}14 \times 0{\cdot}2$ or $0{\cdot}143$ in diameter, anterior surface notched to accommodate the ovary; posterior broader than anterior, front margin depressed and in contact with other testis, $0{\cdot}17 \times 0{\cdot}25-0{\cdot}227$ in size: vitellaria in both fore body and hind body: in former anterior third free, and in latter only up to hind border of testis. Vesicula seminalis distinct, sac-like, behind testis; uterus behind ovary, eggs few, about 5, boat-shaped owing to margins having crumpled, in size $0{\cdot}09-0{\cdot}0929 \times 0{\cdot}042-0{\cdot}046$. Bursa often protruded beyond genital pore which is terminal. In intestine of Pond Heron.

In the peculiar shape of its hold fast organ with entire margin it differs from those species with papillated margin; and from those with entire margins, in the shape of the hold fast organ, the relative sizes of the body regions, the position of the testis and ovary, the form is readily distinguished from the other known species.

12. *Proalaria species inquerenda*

The species of strigeid flukes contained in the Tropical School Collection No. 31 from T. P. Duck, No. 29 from W. T. Sea Eagle and two forms from Osprey and Vulture collected by me, are referable to the above genus. But as I have not yet received papers dealing with complete descriptions of some species with which they appear to resemble, final opinion about them is not expressed at present.

Sub-Family. STRIGEINAE Railliet, 1919

Representatives of this sub-family have been collected from Crested Serpent Eagle, Indian Fishing Eagle, Cattle Egret, Pond Heron, Night Heron, Black-necked Stork, Black-headed Oriole and Hawk Cuckoo. Only such of these as have been sufficiently studied so far are included here.

Genus VII. STRIGEA Abildgaard, 1793

Three species of this genus are recorded.

13. *Strigea elongata* Yamaguti 1935, *variety-indica* n. var.

In Tube No. 7 of the Tropical School of Medicine Collection, from the Black-headed Oriole, were one complete and one broken specimen which, after measuring, were stained and mounted. They resemble closely in form and internal anatomy the Japanese species from Hawk; but differ from them in size of body and also somewhat in sizes of other organs. But as the description given below is based practically on one specimen, I consider it for the present only a new variety.

Description.—Body characteristically like that of *S. elongata* Yamaguti, 1935. Before staining 2.61 long: fore body $1{\cdot}007 \times 0{\cdot}67$; hind body $0{\cdot}1 \times 0{\cdot}6$ in front of ovary, about $1{\cdot}5 \times 0{\cdot}8$ behind ovary: on mounting, it shrank to 2·38, the Japanese form being more than 4·0 long. Oral sucker, terminal, anteriorly directed, $0{\cdot}084 - 0{\cdot}126$: pharynx $0{\cdot}084 - 0{\cdot}117$: acetabulum 0·17 in diameter, in hind part of fore body: lobes of hold fast organ just project beyond anterior rim of fore body: adhesive gland lobulated behind acetabulum. Ovary $0{\cdot}168 \times 0{\cdot}25$, near middle of hind body: testes as in type species, anterior $0{\cdot}46 - 0{\cdot}506 \times 0{\cdot}506$, posterior $0{\cdot}3 \times 0{\cdot}42$: vesicula seminalis, vitellaria and shell gland as in type species: eggs in uterus alongside testes, and in muscular genital cone, surrounding the terminal ducts; about ten in all, size $0{\cdot}08 - 0{\cdot}94 \times 0{\cdot}61 -$

$0{\cdot}67$: sucker-like genital atrium $0{\cdot}252 \times 0{\cdot}336$, opens postero-terminal, with genital papilla projecting into it. In intestine of Black-headed Oriole.

14. *Strigea falconis* var. *eaglesa* n. var.

The specimens form Indian Fishing Eagle, sent to me from Behar, measuring on fixation $2{\cdot}216 - 2{\cdot}72 \times 0{\cdot}058 - 0{\cdot}61$, with their hind body twice as long as fore body, a short genital cone, and vitellaria in fore body, nearly all over but not masking the suckers, and in hind body to commencement of bursa, fall near *S. falconis* Szidat, 1929, according to his useful key. But *S. falconis* measures up to $5{\cdot}0$ long and $1{\cdot}1$ broad, and differs in measurements of internal organs, I consider the Indian form a distinct variety only as, the position of the ovary and other internal organs is the same as in *S. falconis*.

Description.—Fore body $0{\cdot}755 - 0{\cdot}96 \times 0{\cdot}58 \times 0{\cdot}6$, bell-shaped; hind body elongated, nearly of uniform width, $1{\cdot}46 - 1{\cdot}76 \times 0{\cdot}58 - 0{\cdot}59$: oral sucker $0{\cdot}117$ in diameter: pharynx about as long as oral sucker: acetabulum 0 17, about middle length of fore body: hold fast organ with two lobes, protruding partly beyond rim: appear arising from a ring-like basal part (which has still to be studied in sections and may be the lobulated adhesive gland): ovary $0{\cdot}15 - 0{\cdot}168 \times 0{\cdot}21$, $0{\cdot}46 - 0{\cdot}5$ behind commencement of hind body, anterior to middle body: testes large rounded with rugose outline or feebly lobed, posterior more so than anterior; anterior $0{\cdot}3 - 0{\cdot}34 \times 0{\cdot}37$, posterior $0{\cdot}3 - 0{\cdot}38 \times 0{\cdot}336 - 0{\cdot}4$; seminal vesicle large, S-shaped between hind testis and genital cone, bursa prominent, postero-terminal $0{\cdot}26 - 0{\cdot}3 \times 0{\cdot}37 - 0{\cdot}38$, genital papilla protruding into it: eggs 1 or 2, $0{\cdot}084 \times 0{\cdot}0588$.

15. *Strigea globocephalum* n. sp.

A number of examples sent from Behar, but from a different bird, the Crested Serpent Eagle, also

have the same general characters as the above species, but differ from it in body size, about 3.36 long. They have a genital cone resembling that of S. *elongata* Yamaguti rather than of *S. falconis*, Szidat, and differ from both these in the relatively more forward position of the ovary, clearly located within first third of hind body. The testes are also relatively more foward being located in middle third of body. Therefore the form is clearly intermediate between *S. elongata* and *S. falconis*, and given a new name because of its more rounded head part as seen in the majority of specimens examined, in some it appeared vase-shaped.

Description.—Fore body $0{\cdot}84 \times 0{\cdot}84$ $(1{\cdot}24 - 0{\cdot}84)$, usually globular, sometimes vase-shaped, hind body bent dorsally, $2{\cdot}52 - 3{\cdot}2 \times 0{\cdot}8 - 1{\cdot}0$, three to four times as long as fore body: oral sucker, prominent, subterminal, $0{\cdot}126 \times 0{\cdot}16$; pharynx $0{\cdot}126$ in diameter: acetabulum $0{\cdot}21$ in diameter, near hind margin of body: lappets strongly developed, adhesive gland prominent $0{\cdot}336$ in diameter: ovary $0{\cdot}17 - 0{\cdot}21 \times 0{\cdot}25 - 0{\cdot}4$ oval, transverse or oblique, in first third of body, nearly $0{\cdot}7 - 0{\cdot}9$ from junction of body: testes large, contiguous with one another; in side view, anterior $0{\cdot}59 \times 0{\cdot}59 - 0{\cdot}67$, posterior $0{\cdot}67 \times 0{\cdot}59 - 0{\cdot}67$; in middle third of body: vesicula seminalis voluminous with a retort-like posterior part opening on a papilla protruding into the muscular genital cone or sucker, $0{\cdot}25 \times 0{\cdot}33$; bursa with eggs and thick muscular walls, 0.336×0.5, opening terminal: eggs about six to eight in bursa, two or three in uterus, $0{\cdot}1008 - 0{\cdot}117 \times 0{\cdot}059 - 0{\cdot}84$. In intestine of Crested Serpent Eagle.

Genus VIII. APHARYNGOSTRIGEA Ciurea, 1927

Examples of this genus were met with in Cattle Egret, shot by a relation of mine near Patna, in Behar, and the Night Heron, locally. The latter forms resemble very much the Australian species of the genus, *A. simplex*

Johnston, 1904 and therefore not studied in detail. The other one from the Cattle Egret is described below.

16. *Apharyngostrigea egretii* n. sp.

Of the three known species, listed in the Key of Szidat, *A. simplex* (Johnston) is readily distinguished from the above species, as well as from the European form *A. cornu* Geoze (Zeder) because both of them have lobed testes, instead of the entire testes of the Indian fluke. In this respect it is like the Brazilian trematode *A. brasiliana* Szidat, 1929. But the latter has a very different body form, smaller size, and more rounded and backwardly placed testes, besides other differences. Therefore the Indian form is distinctly new.

Description.—Fore body $3{\cdot}1 \times 2{\cdot}5$: hind body $4-4{\cdot}5 \times 2{\cdot}2-2{\cdot}5$: oral sucker 0·18 in diameter, vitellaria over fore body, and also on hind body, but scarce on latter, in thin band along ventral surface: ovary small, oval 0·2–0·3, testes ovoid; anterior, smaller than posterior, transversely elongated in side view: anterior $0{\cdot}336 \times 0{\cdot}4$, posterior $0{\cdot}33 \times 0{\cdot}338$. Eggs $0{\cdot}84 \times 0{\cdot}09-0{\cdot}05-0{\cdot}07$. Other particulars will be given later as the specimens are thick and have not been cut into sections.

Genus IX. COTYLURUS Szidat, 1929

A single specimen of this genus mixed with other forms collected from Bengal, from the Fishing Eagle, was found by me in one tube. The specimen measures about 1·83 in length and has the characteristic 8-like outline of the body. It approaches therefore the species *C. cornutus* Rudolphi, 1809, in size and differs from all the rest. But the Indian forms differ from Rudolphi's species in its characteristically lobed testes, with rugose margin. Therefore a new species is created for it.

17. *Cotylurus streptocorpus* n. sp.

Description.—Fore body $0·756 \times 1·08$, nearly rounded, broader than long; hind body $1·08 \times 0·71$, about as long as the fore body is broad: oral sucker, $0·126 \times 0·21$, a short distance back of the extremity: acetabulum 0·33 behind front margin, poorly developed $0·1 \times 0·08$: hold fast organ with lappets of the usual type arising from a common base: vitellaria extend into fore body: ovary bean-shaped, posteriorly notched, transverse, $0·126 \times 0·185$; testes transversely elongated, with lobulated margins, ovary and testes close behind one another in middle third of hind body; anterior $0·26 \times 0·63$, posterior $0·21 \times 0·59$: bursa, bulbous with muscular walls: eggs not present in the specimen. In intestine of Fishing Eagle.

Genus X. OPHIOSOMA Szidat, 1929

Two representatives of this genus have so far been met with.

18. *Ophisoma microcephalum* Szidat, 1929

A number of specimens resembling this species were collected from herons, locally, and I believe them to be the same species.

19. *Ophiosoma macrocephala* n. sp.

Few specimens collected from Hawk Cuckoo, measuring in life 3 – 5 long; but on fixation the average size is about 2·75 – 3·1. The form is not so elongated as that of *O. wedlii* nor the head relatively so small as that of *O. microcephala*, the only two known forms of the genus. The hind body is only three to four times as large as the fore body.

Description.—Fore body $0{\cdot}84 - 1{\cdot}01 \times 0{\cdot}58 - 0{\cdot}63$, with narrow, anteriorly directed opening with lobed margin, containing few scattered vitelline follicles hind body about as thick as fore body, in middle, somewhat narrower towards both ends, $1{\cdot}93 - 2{\cdot}6 \times 0{\cdot}67$: vitelline follicles dense ahead of ovary, thin in narrow band along ventral side to bursa : ovary at 1·007 behind junction, $0{\cdot}126 \times 0{\cdot}21$, testes, in side view deeply notched, with nearly smooth margin, not indented as in *O. wedlii*: anterior $0{\cdot}336 \times 0{\cdot}336$; posterior $0{\cdot}34 \times 0{\cdot}46$: vas deferens very wide, vesicula seminalis prominent between hind testis and bursa : bursa muscular, postero-terminal, opening wide : eggs not present. In intestine of Hawk Cuckoo.

Genus XI. *RIDGEWORTHIA* n. gen.

Generic diagnosis.—Strigeinae Railliet, 1919. Body divided into a broad, short fore body, gradually merging into the hind body. Margins of fore body united to form a deep goblet, opening anteriorly. Oral sucker subterminal, with two muscular patches at lateral corners of fore body, somewhat like those in *Pulvinifer* Yamaguti, 1933. Acetabulum well developed about middle. Pharynx indiscernible. Oesophagus short. Intestinal caeca to posterior end of body. Hold fast organ a peculiar muscular ridge bent upon itself lying behind acetabulum with a prominant adhesive gland behind. Hind body cylindrical about one and a half to nearly twice the length of fore body. Ovary roundish about middle of hind body. Testes in side view elongated antero-dorsally, otherwise squarish with feebly crenulated margins. Anterior testis separated from ovary by a short distance. Posterior testis touches anterior. Vesicula seminalis not voluminous. Cirrus and cirrus pouch absent, vitellaria extending throughout fore and hind body. Uterus reaches near adhesive gland. Hermaphroditic canal present. Bursa with muscular

wall. [Other particulars will be furnished in the complete paper.]

20. *Ridgeworthia ramai* n. sp.

Description.—A number of specimens from the Night Heron displayed a very peculiar and characteristic muscular hold fast organ, twisted upon itself in a prominent fashion like a broad ridge. This character is not met within any known genera hence a new genus erected with above diagnosis. As all available material is pressed and mounted other details will be furnished later. Body length $3{\cdot}27-4{\cdot}14$: fore body $1{\cdot}08-1{\cdot}17 \times 0{\cdot}85-0{\cdot}86$: hind body $2{\cdot}1-3{\cdot}06 \times 0{\cdot}37-0{\cdot}46$: oral sucker $0{\cdot}15$ in diameter : a muscular depression on either side of antero-lateral margin of fore body : pharynx not seen. Acetabulum $0{\cdot}35-0{\cdot}37$ distant, $0{\cdot}15-0{\cdot}2$ in diameter : hold fast organ $0{\cdot}42 \times 0{\cdot}547$, ovary $0{\cdot}17 \times 0{\cdot}29$; anterior testis $0{\cdot}35 \times 0{\cdot}17$ (side view), $0{\cdot}336 \times 0{\cdot}336$ (dorsal view); posterior $0{\cdot}42 \times 0{\cdot}17$ (side view), $0{\cdot}336 \times 0{\cdot}42$ (dorsal view); post testicular distance $0{\cdot}506$. Uterus with many eggs $0{\cdot}084-0{\cdot}092 \times 0{\cdot}05-0{\cdot}07$: bursa postero terminal. In intestine of Herons.

21. *Holostomum Serpens*

Some specimens resembling the above species have been obtained from Black-necked Stork about $4-5$ long. But they have not yet been completely studied. The hind body has a long neck, with all the generative organs located at the hind extremity into bulb-like expansion.

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N.B.—Owing to sufficient space not being available in this issue, the paper is cut short here, and called Part I.